Apr '47

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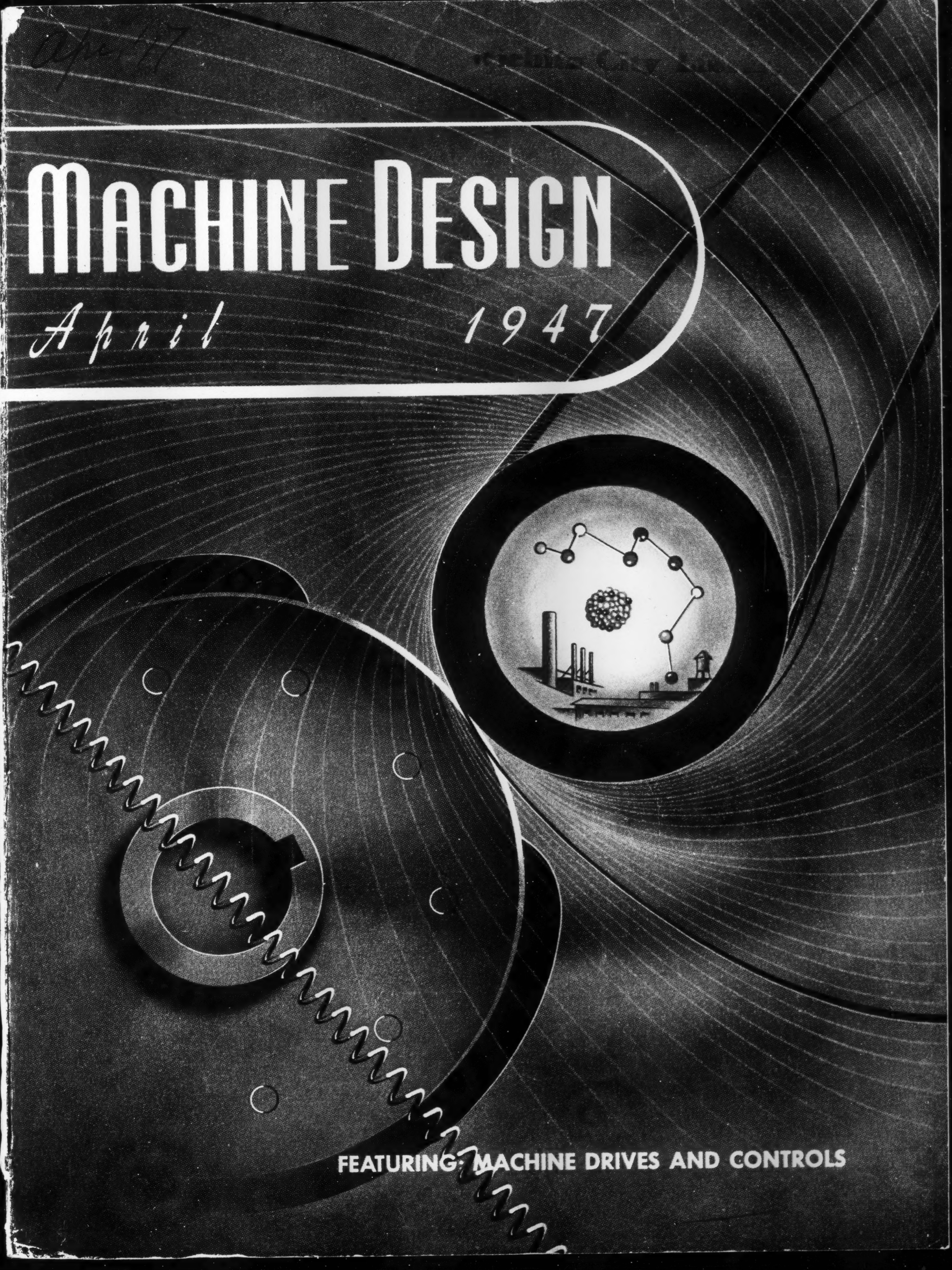
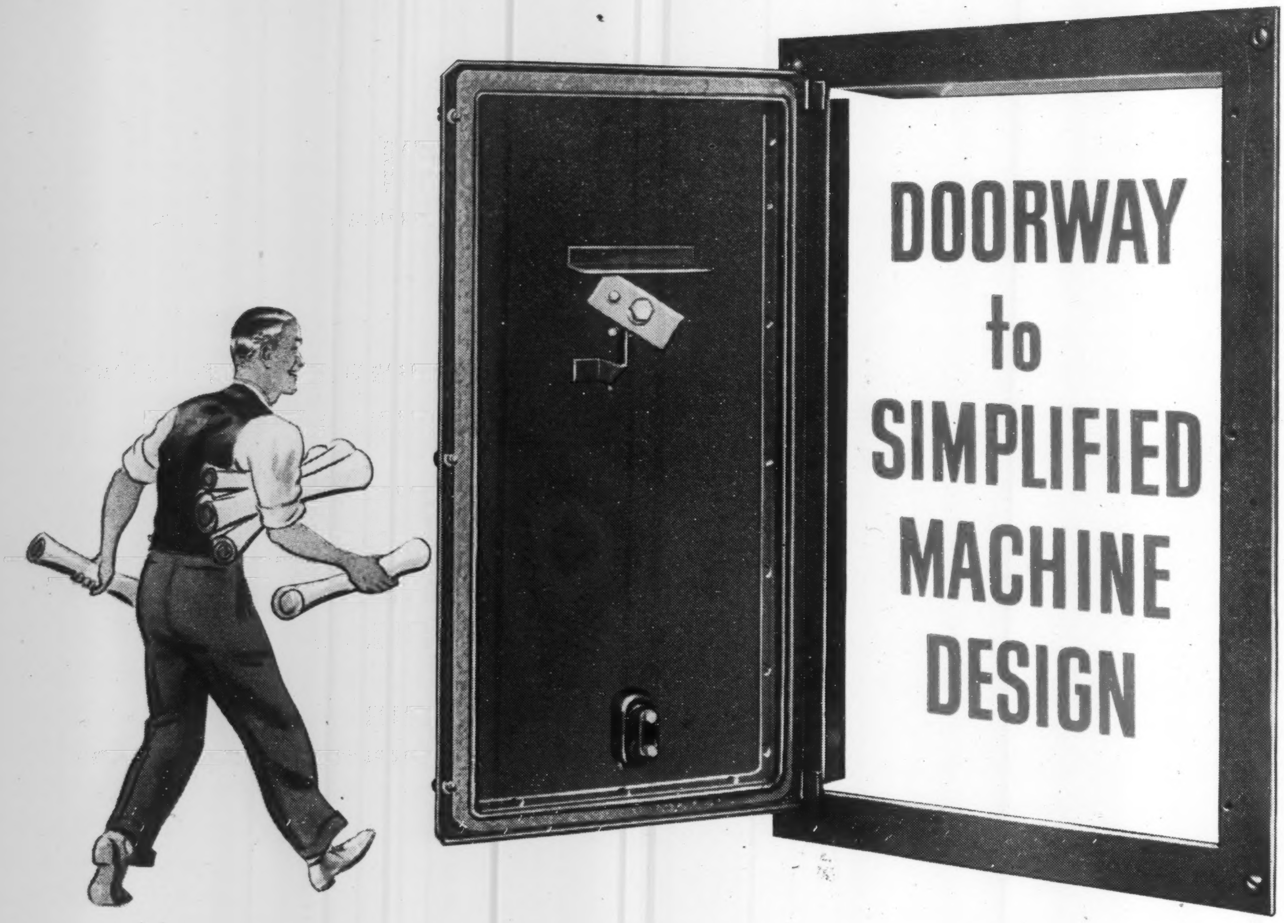
MACHINE DESIGN

April 1947

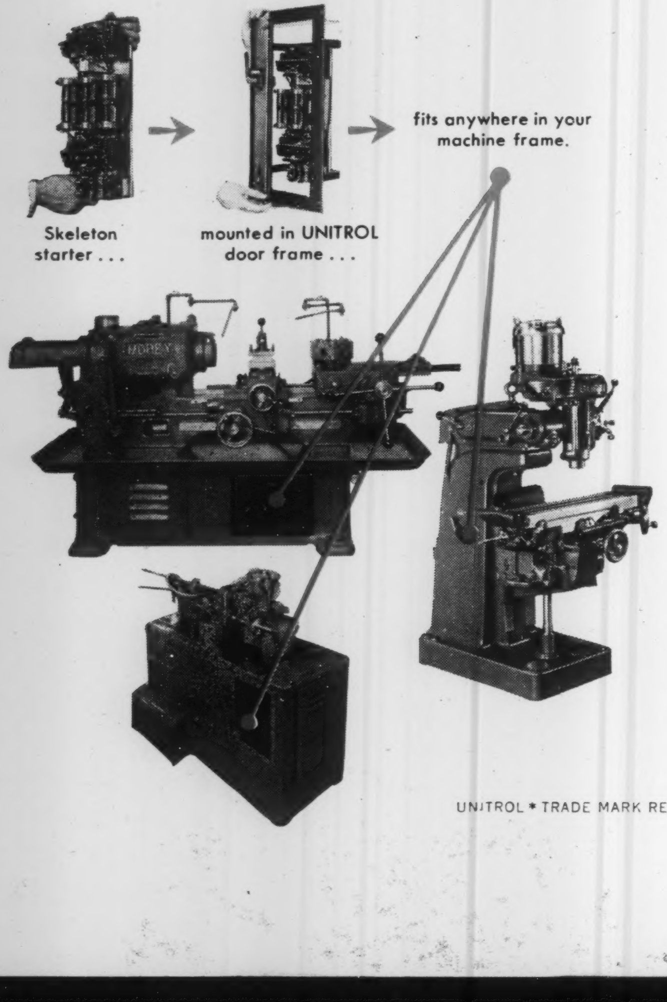


FEATURING: MACHINE DRIVES AND CONTROLS



DOORWAY to SIMPLIFIED MACHINE DESIGN

UNITROL . . . the In-a-door control . . . solves the built-in control problem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mounted in UNITROL door frame . . .
fits anywhere in your machine frame.

UNITROL, the better method of housing starters and other control elements for use in machine design . . . consists of the skeleton motor control mounted in a UNITROL door frame. This assembly possesses extreme flexibility of application. You cast or cut an opening in the frame of your machine and by means of mounting screws, fasten UNITROL into place. It saves assembly, mounting and wiring time. It gives cleaner lines to your machine. It saves material costs . . . no inside mounting base, no outside enclosing case. It makes all control elements easily accessible for use and for servicing. UNITROL is the mark of the modern machine. It means a better machine at a lower cost.

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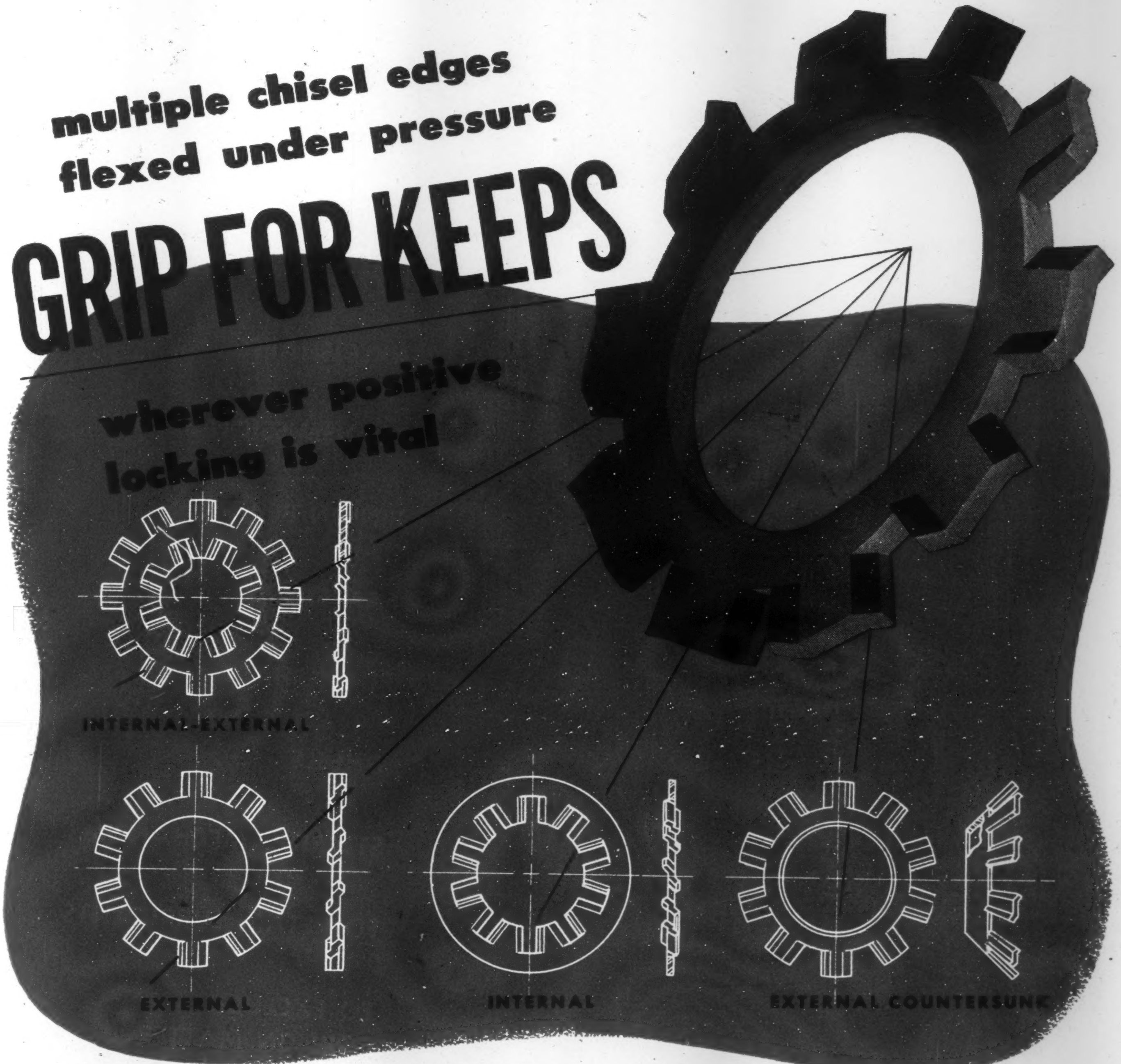
multiple chisel edges
flexed under pressure
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wherever positive
locking is vital
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EXTERNAL
INTERNAL
EXTERNAL COUNTERSUNK

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THE WASHER THAT HAS THE EDGE

This patented design is exclusive to EverLOCK. The numerous tongues, the wide chisel edges of which are bent alternately up and down, provide several times more gripping area than other lock washers. The alternating chisel edges, forced into the contiguous faces of both work and nut by powerful spring tension, provide a 2-way locking action that defies every conceivable loosening hazard. That's why you'll find EverLOCK washers guarding vital assemblies on so much heavy machinery, electrical appliances, automotive and aviation equipment.

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MACHINE DESIGN
April 1947

THIS MONTH'S COVER: Symbolic portrayal of machine drives and controls. Artist Roland Veit utilizes a colorful highspot to indicate the vast potentialities in controlling atomic energy as a source of power for machine drives.

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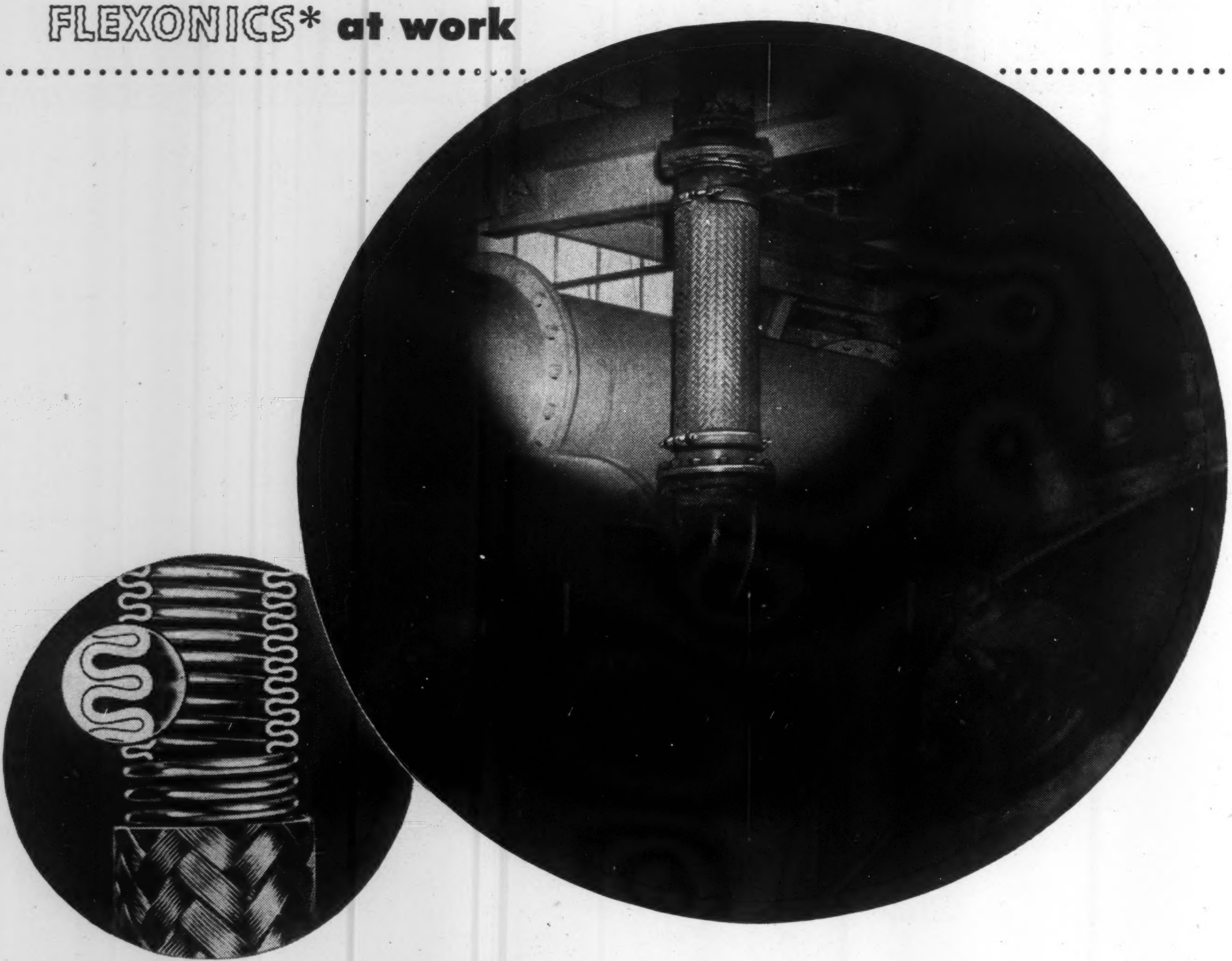
FLEXONICS* at work



DAMPENING VIBRATION and NOISE in piping systems

PROBLEM: Operating personnel in a large power plant was experiencing equipment damage due to vibration and failures of pipe lines carrying compressed air to various plant stations. The problem was to locate the source of trouble and correct it.

SOLUTION: Chicago Metal Hose engineers were consulted and through their knowledge of the science of FLEXONICS,* recommended the installation of *Rex Vibra-Sorbers* at determinable locations in the piping system.

RESULT: Line failures ceased when transmitted vibration was absorbed by *Rex Vibra-Sorbers* (available in various alloys). Disturbing noise also was eliminated. When you have a vibration problem, ask for a C.M.H. engineer and he'll help you reach a satisfactory solution!

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"The controlled bending of thin metals for use under varying conditions of temperature, pressure, vibration and corrosion" . . . is exemplified in the basic products of Chicago Metal Hose Corporation.

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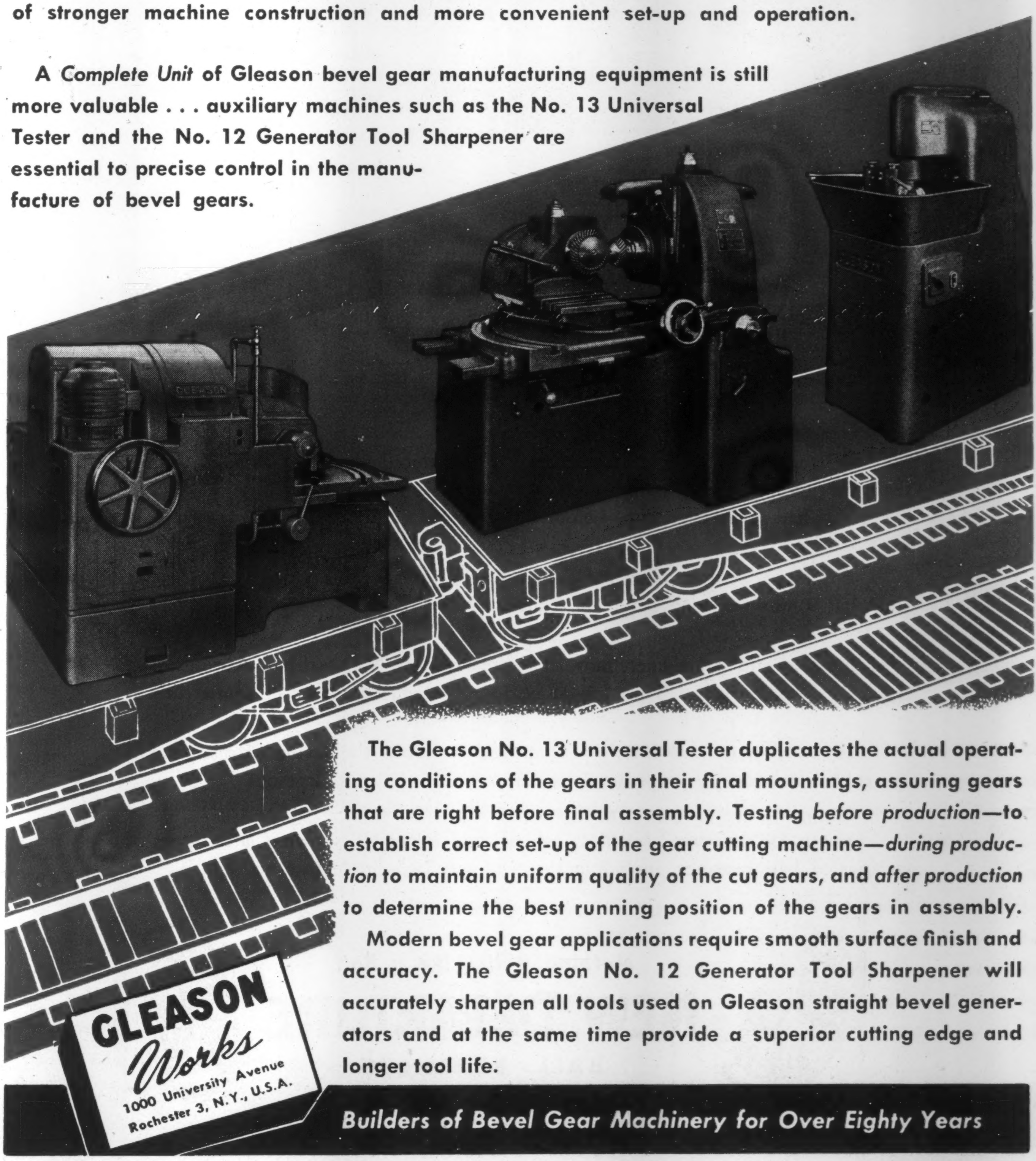
A Gleason 12⅞" Straight Bevel Generator is a valuable addition to any plant where straight bevel gears are required . . . with localized tooth bearing for coniflex gears, faster cutting speeds because of stronger machine construction and more convenient set-up and operation.

A *Complete Unit* of Gleason bevel gear manufacturing equipment is still more valuable . . . auxiliary machines such as the No. 13 Universal Tester and the No. 12 Generator Tool Sharpener are essential to precise control in the manufacture of bevel gears.



The Gleason No. 13 Universal Tester duplicates the actual operating conditions of the gears in their final mountings, assuring gears that are right before final assembly. Testing *before production*—to establish correct set-up of the gear cutting machine—*during production* to maintain uniform quality of the cut gears, and *after production* to determine the best running position of the gears in assembly.

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"Lubricated-for-Life"

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Now, twenty years later, more than 110 million N-D-seal ball bearings have been used successfully. They are to be found wherever wheels or shafts turn.

The advantages are briefly:, Simplified assembly, the saving of many small parts, no maintenance expense, lubricant kept in — dirt is kept out.

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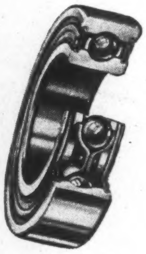
Nothing Rolls Like a Ball

NEW DEPARTURE

BALL BEARINGS



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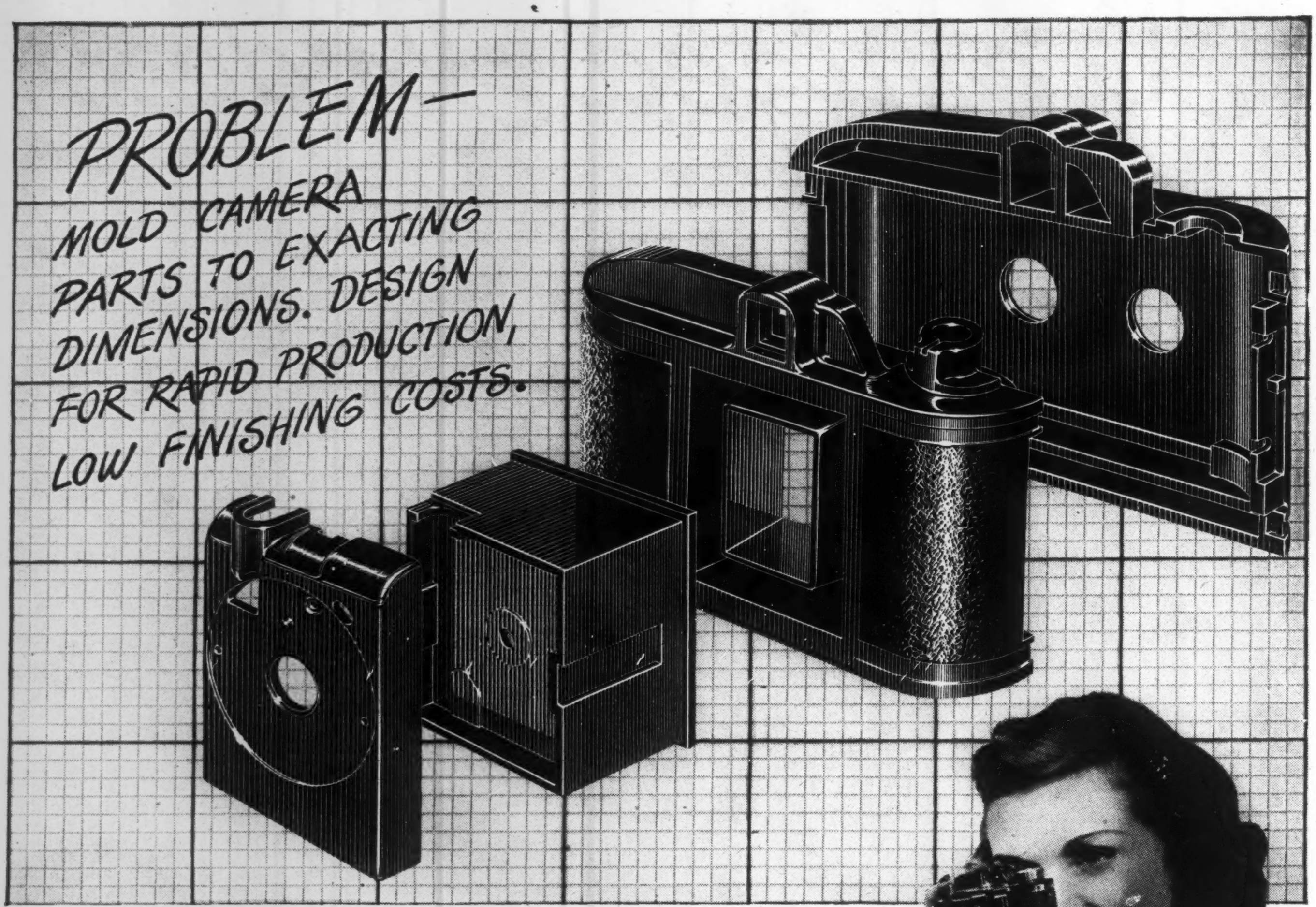
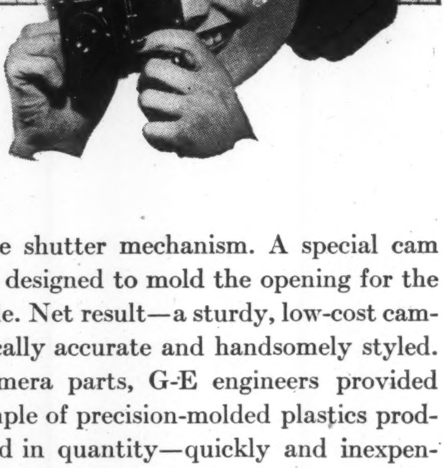
DESIGN PROBLEMS IN MOLDING PLASTICS PARTS

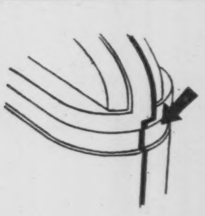

PROBLEM—
MOLD CAMERA PARTS TO EXACTING DIMENSIONS. DESIGN FOR RAPID PRODUCTION, LOW FINISHING COSTS.



HERE'S A CAMERA DESIGN—FOCUSED ON PLASTICS

● When Whitehouse Products, Inc., planned its Beacon camera, plastics came into the picture. Camera parts must be precision made—for protection against light-leakage and for accurate lens mounting. Inner surfaces must be free from roughness that would harm the film.

The problem of producing these parts without high finishing costs was brought to No. 1 Plastics Avenue. General Electric engineers recommended compression-molding a black phenolic that gives a high, glossy finish and resists warping. In addition to the lens mountings, design requirements included a built-in view finder and a housing for the shutter mechanism. A special cam arrangement was designed to mold the opening for the film-winder handle. Net result—a sturdy, low-cost camera housing, optically accurate and handsomely styled.



PERFECT ALIGNMENT ASSURED BY HIGH PRECISION MOLDS

Precision molding of back and front of the camera make possible so perfect a fit that problems of light-leakage or misalignment of parts are eliminated.

With these camera parts, G-E engineers provided still another example of precision-molded plastics products manufactured in quantity—quickly and inexpensively. You may be able to save time and money the same way. Take advantage of General Electric's *complete* plastics service. Bring your plastics design and production problems to General Electric—the world's largest manufacturer of finished plastics products. Send for the new G-E bulletin, "Design Data on Plastics for Product Designers." Write to Section G-14, Plastics Division, Chemical Department, General Electric Co., 1 Plastics Avenue, Pittsfield, Massachusetts.

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VERSATILE OILGEAR *Fluid Power*

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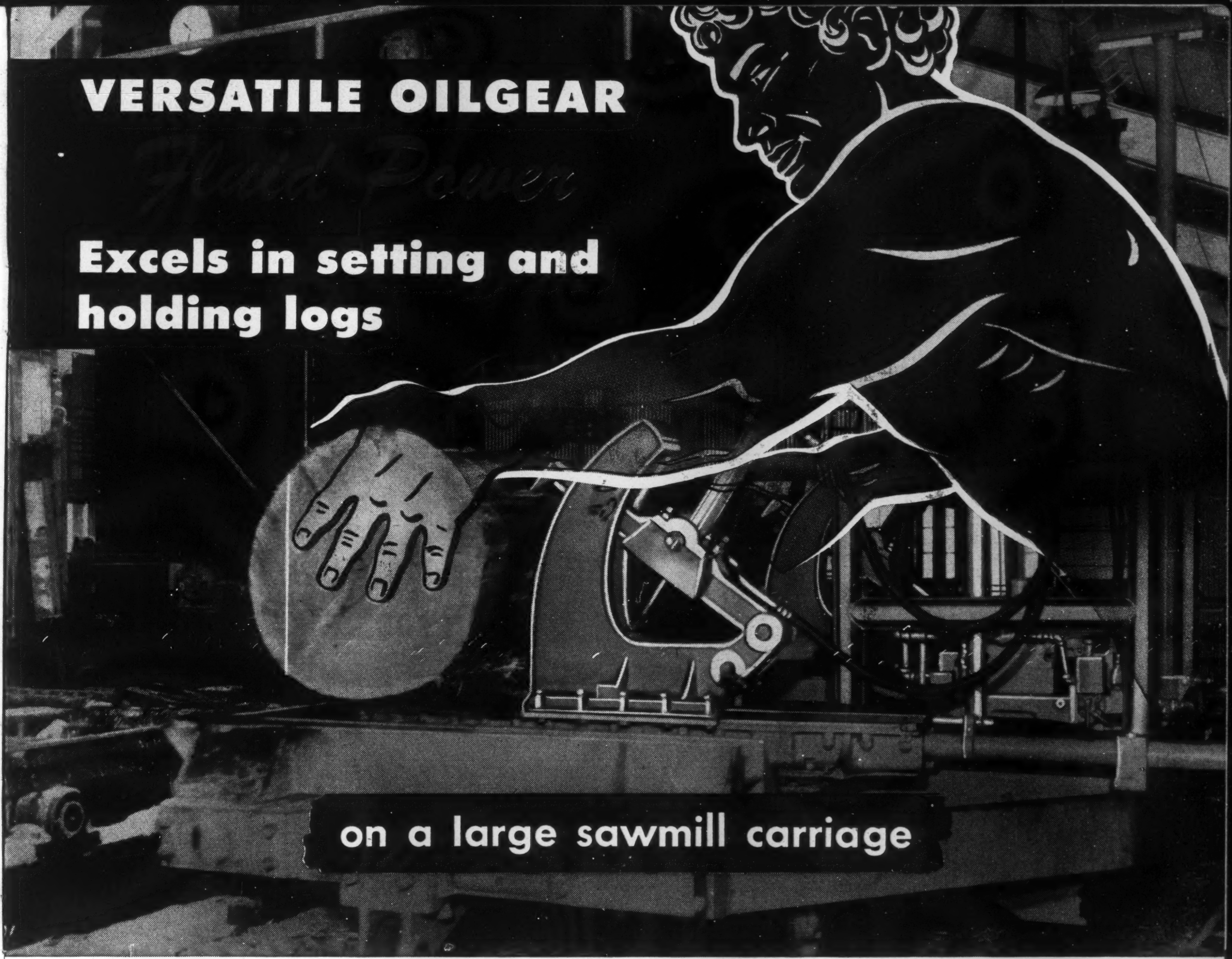

on a large sawmill carriage

Logs larger than 40 inches diameter must be sawed into cants before they are fed to the chipper in this mill. Speed in grabbing and spotting the log for band sawing is vital. Experience shows no power can be applied or reversed as smoothly and rapidly as fluid power so the Soundview Pulp Co. of Everett, Washington, selected Oilgear, foremost in fluid power, to operate the setworks and holding dogs on their sawmill carriage.

Two Oilgear fluid power pumps supply a sudden thrust of power to two dog cylinders for gripping the long log, they maintain a pre-selected pressure on the dogs indefinitely without power-loss or overheating and they actuate two setworks cylinders to quickly move the large log to and from the sawing position.

The above is only one of many applications of Oilgear Fluid Power in the lumber, pulp and paper industries. This versatile power performs any conventional rotary, straightline or reciprocating function besides a number of others that cannot be performed with other power transmission equipment. Write for further information or ask an Oilgear engineer to show you how Oilgear Fluid Power can solve your problem. THE OILGEAR COMPANY, 1305 W. Bruce St., Milwaukee 4, Wisconsin.

Typical Oilgear uses in lumber, pulp and paper mills

Drives for log carriages, barkers, turners, niggers, paper machines, calenders, winders, unwinders, etc.... Feeds for carriages, edger rolls, surfacers, saws, etc.... Holddowns for pulp grinders, paper machine presses, calenders, etc....

Oilgear Fluid Power

OILGEAR

ARE YOU TRYING TO:

1. Apply large forces through long . . . or short . . . strokes at variable speeds?
2. Obtain automatic work cycles, variable speeds in either direction . . with or without preset time dwell?
3. Apply large forces through continuous or intermittent reciprocating cycles at constant or variable velocities?
4. Obtain extremely accurate control of either position or speed of a reciprocating member?
5. Apply accurately variable pressure either static or in motion?
6. Closely synchronize various motions, operations or functions?
7. Apply light . . or heavy . . . forces at extremely high velocities through either long or short distances of travel?
8. Obtain continuous automatic reversing drives at constant R.P.M. or over a wide range of speed variation?
9. Obtain accurate remote control of speed and direction of rotation, rates of acceleration and/or deceleration?
10. Obtain constant horsepower output through all or part of a speed range?
11. Obtain automatic torque control?
12. Obtain accurately matched speed of various rotating elements?
13. Obtain constant speed output from a variable speed input?
14. Obtain full preset automatic control. elimination of problems of shock, vibration, etc.?

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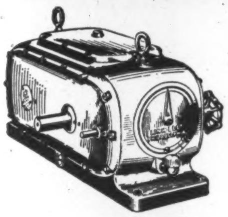
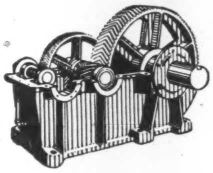


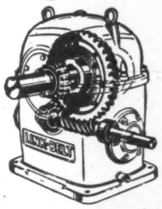
P.I.V. Gear Speed Changer

Permits infinite variation of speed while machine is running; holds set speed indefinitely, without slip or creep. All metal, wholly enclosed. ½ to 15 h.p. vertical, horizontal, plain, motorized or with extra reduction gears. Book 1874 tells all!



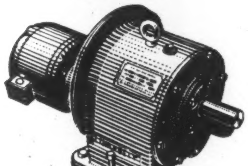
Herringbone Gear Speed Reducer

For low and medium speeds, heavy-duty applications where large reductions and shock loads are encountered. Single, double and triple reductions. Complete details in Data Book 1519-A.



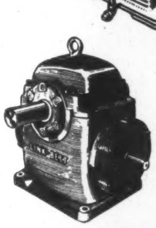
Worm Gear Speed Reducer

Suited to high ratio reductions, with vertical or horizontal output shafts. Quiet, smooth operation, compact, simple and flexible, adaptable to many applications. Details in Book 1824.



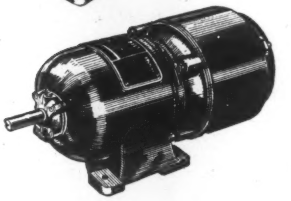
Motorized Helical Gear Speed Reducer

Simple, compact, self-contained power units for medium speed applications from 1 to 75 h.p. Details and application data in Book 1515-A.



Fan Cooled Worm Gear Speed Reducer

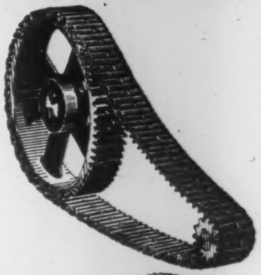
Delivers equivalent horsepower of a much larger unit, because cooled by internal fan. Permits more compact design and assures lower cost per transmitted horsepower. Send for details.



Electrofluid Drive

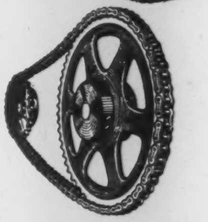
Combined standard induction motor with hydraulic coupling, for smooth starting—protecting motor and driven machine against shock load. Size of motor is based on running h.p., not on starting requirements. 1 to 20 h.p. Send for Book 2085.

A Link-Belt power transmission engineer has no one's ax to grind—except his customer's. Not confined by a limited line—he can recommend the type of speed reducer—the type of bearing—the type of chain drive—the exact power transmission units best suited to his customer's needs. Link-Belt engineering advice on your power transmission problems is completely unbiased. There is no reason for it to be otherwise.



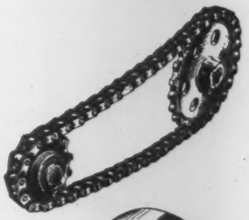
Silent Chain Drive

Gives positive, flexible transmission without slip at high speeds. Runs slack on short centers. Usually lowest cost installation; always lowest yearly cost. Unaffected by climatic conditions or periodic idleness. Ask for Data Book 125.



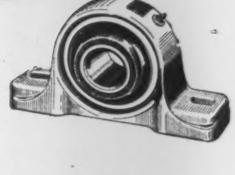
Roller Chain Drive

For transmitting power at high or low speeds, coordinating rotation of numerous shafts, in either direction; for short or long centers; runs slack and is unaffected by temperature or moisture. Details in Book 1957. Single or multiple widths.



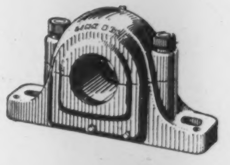
Steel, Promal and Malleable Chain Drives

For slow and medium speeds or where extraordinary strength is needed, L-B Steel, Promal and Malleable Iron chains are the standard by which performance is gauged. Standard types have been developed to meet various services. Data Book 1994.



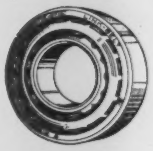
Ball Bearing Mounted Units

Light and medium duty series, pillow blocks with solid or split housings, and flanged, cartridge or take-up units, self-aligning and fixed or floating types. Full details in Book 2094.



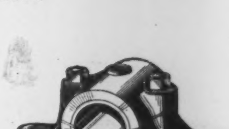
Roller Bearing Mounted Units

For heavy-duty service, made in split housing pillow blocks. Self-aligning, for fixed or floating shafts, and press fit or adapter type. Full data in Book 2095.



Unmounted Ball and Roller Bearings

Provide self-alignment for radial, thrust, or combinations of radial-thrust loads for all degrees of misalignment. Offer great economy of application. Details in Books 2094 and 2095.



Babbitted Bearings

In a complete line including the widest selection of types of solid and split housings, grease lubricated or self-oiling, for light and heavy service. Popular types and sizes in stock. Data in Book 1997.

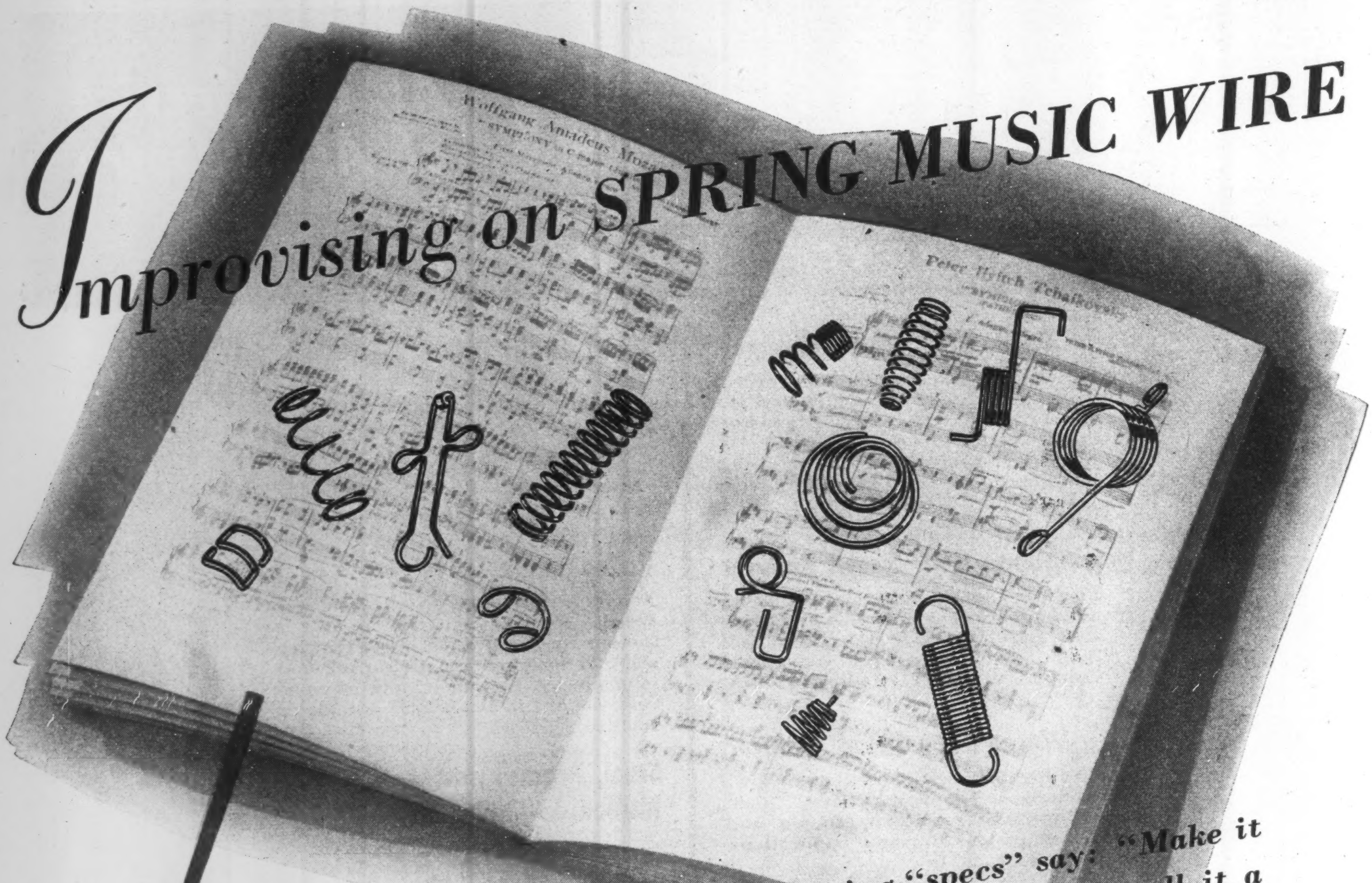
LINK-BELT COMPANY

The Leading Manufacturer of Conveying and Mechanical Power Transmission Machinery

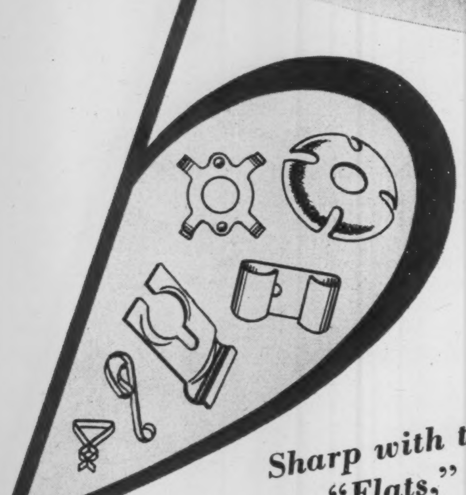
Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24,
Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

10,552

Improvising on SPRING MUSIC WIRE



When spring "specs" say: "Make it of music wire"—we could call it a day. Music wire is a well-known standard product and lots of springs are made of it. But with a particular eye to production and performance balance, we use several kinds of music wire, each keyed to special uses. By broadening the field of "standards," Wallace Barnes provides additional possibilities for quality control and economy in springmaking.



Sharp with the "Flats," too!

For flat springs and small stamped parts, Wallace Barnes also processes in its own mill many tempers and hardnesses of spring steel to meet requirements of intricacy or endurance.

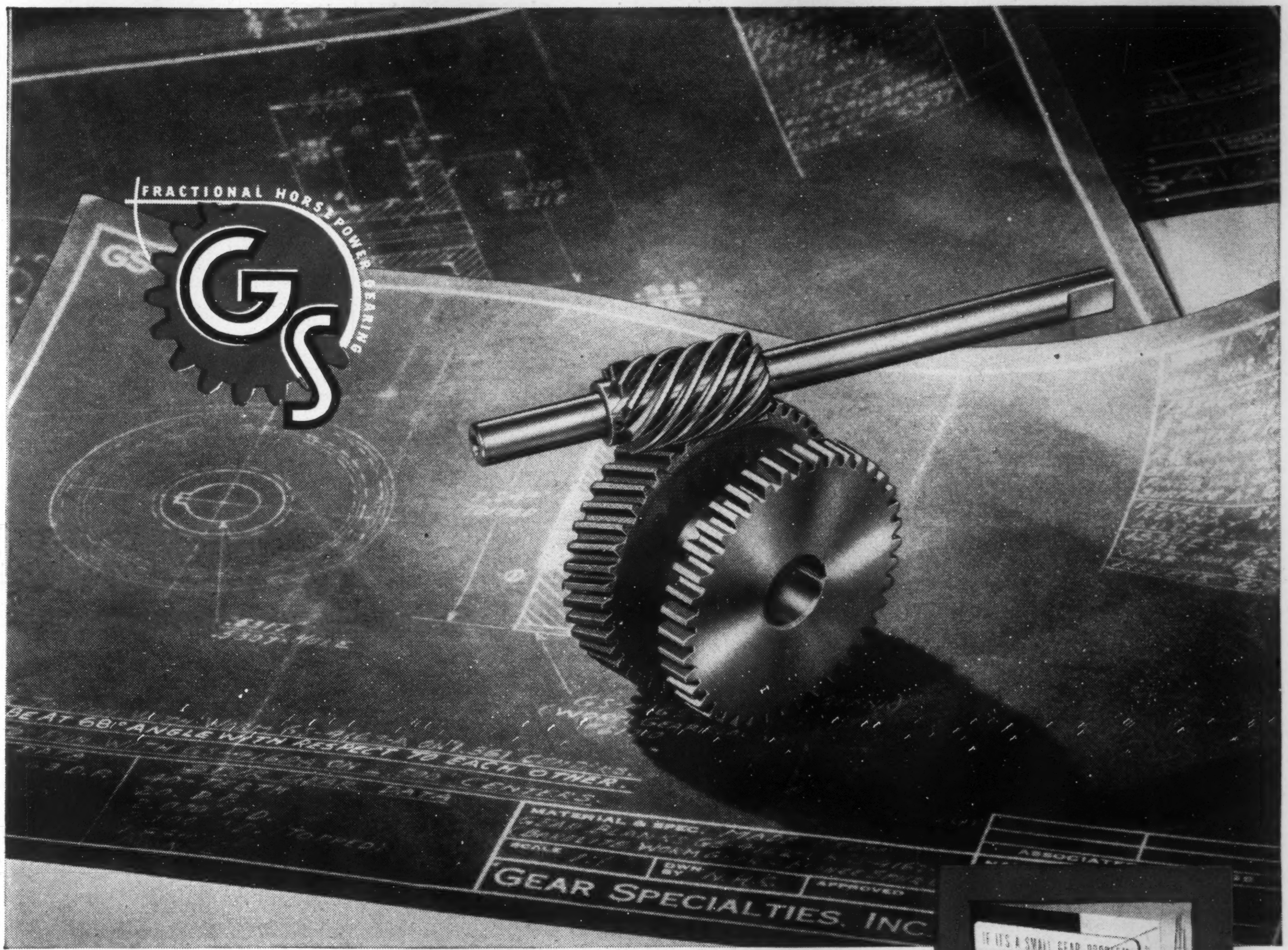
Wallace Barnes SPRINGS

SMALL STAMPINGS • WIRE FORMS • HAIRSPRINGS • COLD ROLLED SPRING STEEL

WALLACE BARNES COMPANY
BRISTOL, CONN.

DIVISION OF THE ASSOCIATED SPRING CORP.

AND IN CANADA, THE WALLACE BARNES CO., LTD., HAMILTON, ONTARIO


FRACTIONAL HORSEPOWER GEARING
GS
BE AT 68° ANGLE WITH RESPECT TO EACH OTHER.
MATERIAL & SPEC.
SCALE
DWN BY
APPROVED
ASSOCIATE
GEAR SPECIALTIES, INC.

IF IT'S A SMALL GEAR PROBLEM
Ask G-S
GEAR Specialties

SEND FOR OUR 4-PAGE BULLETIN

The G-S Bulletin describes many different types and applications of G-S Small Gears. Please ask for a copy on company stationery.

CUSTOM MADE FOR PARTICULAR PEOPLE

MANY of America's biggest buyers specify "G-S" when they want Small Gears. And many more smaller but no less *particular people* come to us regularly for gears custom made to the highest standards of uniform accuracy. If your needs are enough for a production run, by all means discuss the job with our capable engineers. Get all the advantages only a quarter century of *intensive* specialization can give. See why we have become recognized as the "World's Largest Exclusive Manufacturers of Fractional Horsepower Gears!"

GEAR Specialties

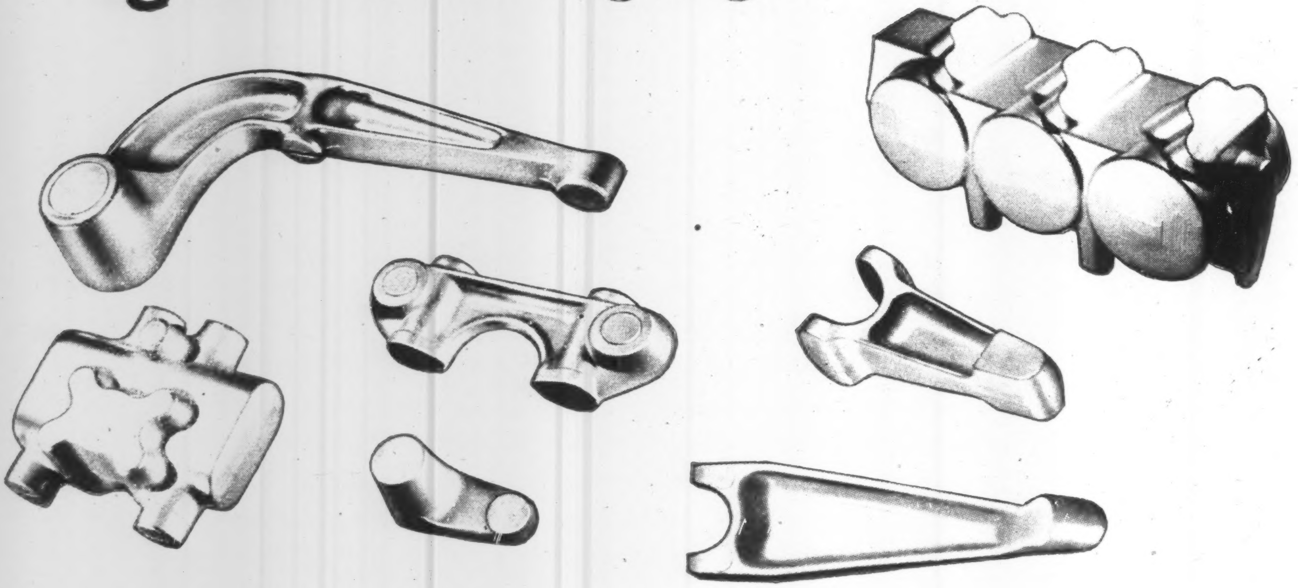
Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

agnesium *Forgings*



6.5	.02	1.0	Remainder	For press forgings of good strength and resistance to salt water.
..	1.5	..	Remainder	Moderate strength alloy. Can be used for both press and hammer forgings.
8.5	0.2	0.5	Remainder	Highest strength press forgings of simple design. Available in as forged, aged, or heat treated and aged conditions depending upon strength requirements.

As forged	43,000	38,000	26,000	22,000	12	6	17,000	55	66	16,000
As forged	36,000	30,000	23,000	18,000	7	5	......	47	54	......
As forged	46,000	42,000	31,000	26,000	8	5	25,000	69	80	18,000
Aged	50,000	42,000	34,000	28,000	6	2	28,000	72	82	16,000
Heat Treated and Aged	50,000	42,000	34,000	28,000	5	2	27,000	72	82	16,000

[1] Unless otherwise designated, values are typical. Minimum property values are guaranteed only when specified by the customer.

[2] Yield strength is defined as the stress at which the stress-strain curve deviates 0.2% from the modulus line.

[3] Properties for M alloy are based on both press and hammer forgings, those for J-1 and O-1 on press forgings only.

This advertisement is adapted from the Dow Magnesium Catalog in Sweet's File for Product Designers.
See Sweet's or ask Dow for the complete catalog.

MAGNESIUM GIVES YOU

Pressure Tightness • Good Fatigue Strength!

ADVANTAGES: Magnesium can readily be forged to provide high strength for applications where highly stressed parts must have light weight. Magnesium forgings have good fatigue strength, which makes them suited for parts which must withstand repeated stresses. In addition, they are especially sound, which makes them desirable for applications requiring pressure tightness. The advantages obtained by forging other metals are also obtained with magnesium alloys, plus the additional advantages of extremely light weight.

Since magnesium forgings are normally used for highly stressed applications, correct design principles must be adhered to in order to eliminate stress concentration and highly concentrated loads. This factor, however, does not eliminate magnesium from forgings of complicated design. Such forgings may be roughly forged to size, permitting the parts to possess the high properties of forgings, and machined to the final and complicated shapes. Thus the superior machinability of magnesium adds to the advantages of magnesium forgings.

Hydraulic forging presses are best suited for magnesium work. However, slow acting mechanical presses and forging hammers are also used.

SHAPES AND SIZES: Magnesium forgings can be produced in the same variety of shapes and sizes as forgings of other metals. The maximum size is limited primarily by the size of available equipment.

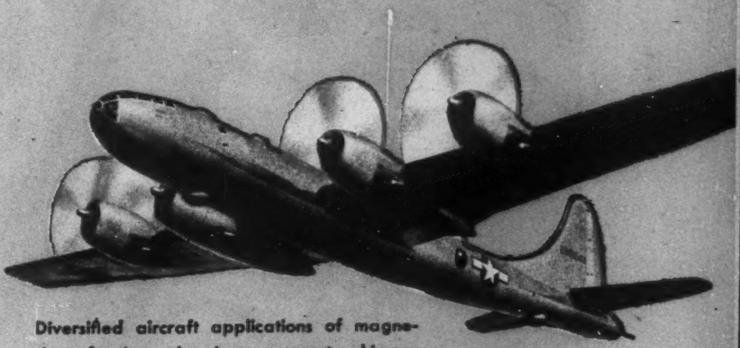
The tolerances on magnesium forgings can be held to the same values as in normal forging practice with other metals. These tolerances will vary somewhat with the size and design of the forging. The tolerances range from plus or minus 0.010 inch on dimensions under 2 inches (with an additional plus or minus 0.003 inch for each additional inch of length or width) to plus or minus $\frac{1}{32}$ to $\frac{1}{16}$ inch on dimensions across the parting line.

MAGNESIUM DIVISION
THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

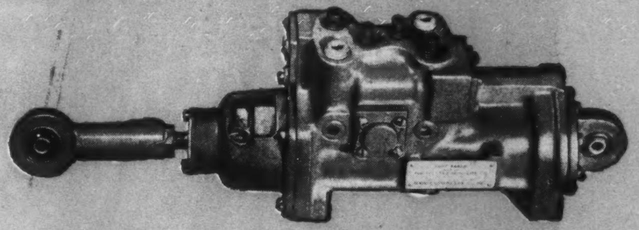
New York • Boston • Philadelphia • Washington
Cleveland • Detroit • Chicago • St. Louis • Houston
San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Ontario

DOW

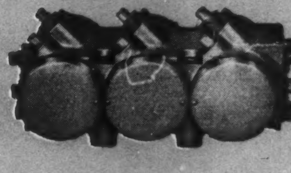
DOWMETAL

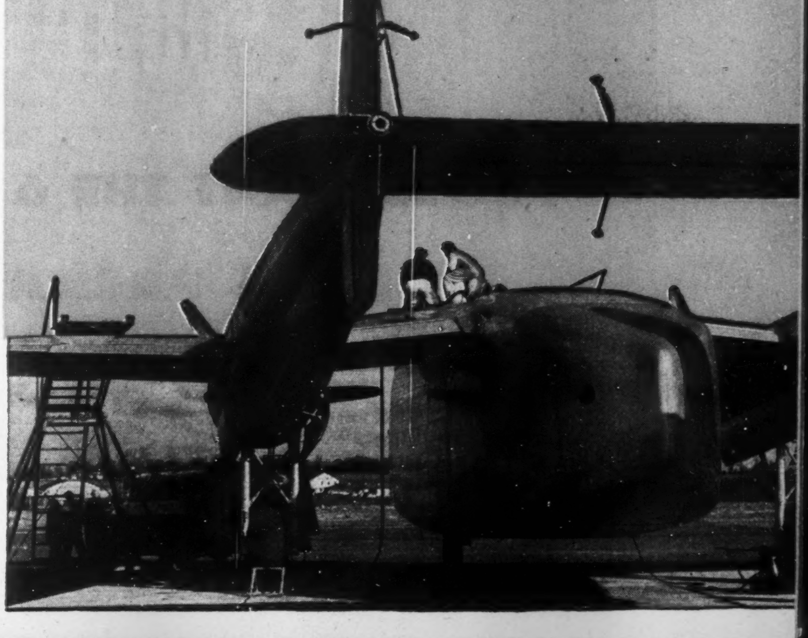


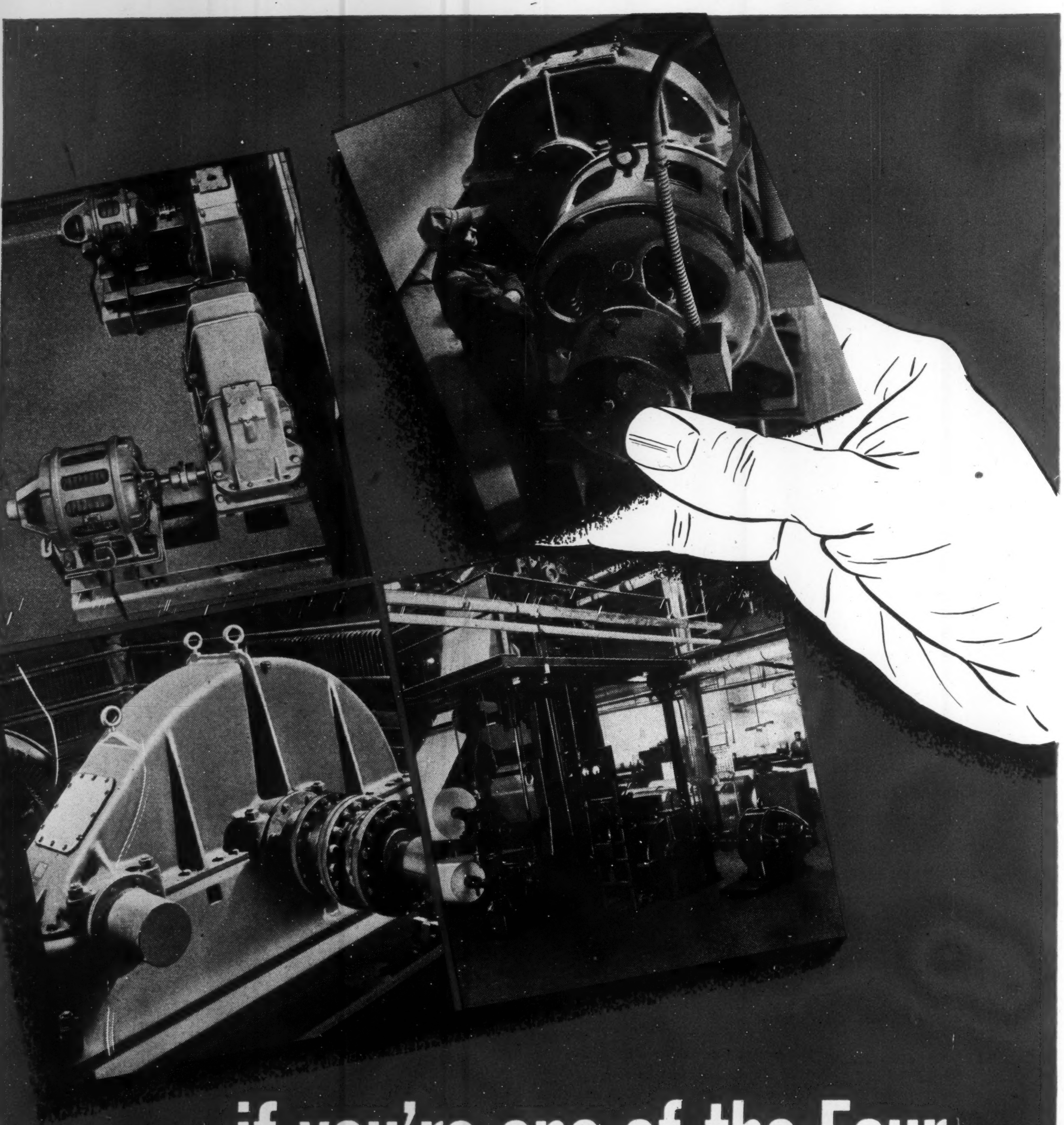
Diversified aircraft applications of magnesium forgings—housings, supports, hinges, mountings, and many other parts—point to broad usefulness in other industries.



Magnesium forgings form the bodies of both the hydraulic servo cylinder of the Sperry S-4 automatic pilot (above) and the transfer valve of the Sperry Mark IV automatic pilot (below). Photographs courtesy Sperry Gyroscope Company, Inc.





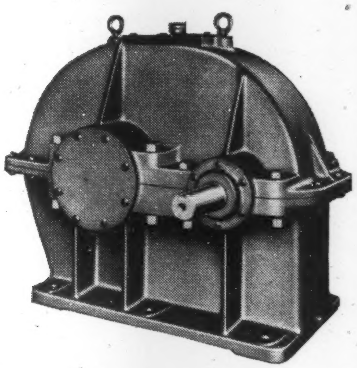


if you're one of the Four...

YOU'LL WANT THE 6 BENEFITS OF THIS PACKAGED DRIVE

WESTINGHOUSE

MEMBER OF AGMA



This Type SH speed reducer is a single-reduction unit which is furnished in thirteen standard ratios in each of twelve sizes. The Type DH speed reducer, which is a double-reduction unit, is offered in fifteen standard ratios in each of twelve sizes.

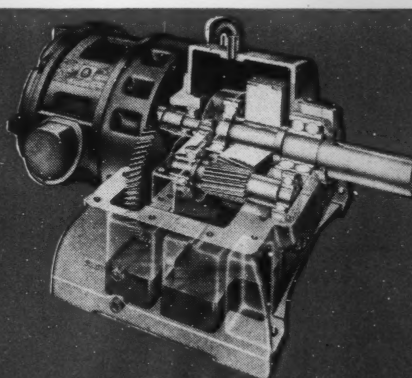
If your machines are among the four out of five that run slower than their prime movers, here are six ways you can profit by using Westinghouse speed reducers:

1. Improved power efficiency (one plant raised it from 80.9% to 85.4%).
2. Fewer inspections . . . only semiannual lubrication needed.
3. Maintain positive alignment of drive and driven machine.
4. Long service life through single helical gearing, specially heat-treated by exclusive Westinghouse BPT process.
5. Minimum power loss with antifriction bearings.
6. Precision operation from hot-cut gears.

Add to these benefits the advantage of unit responsibility with both motors and gear supplied by one manufacturer. You have your choice of twenty-four sizes of Westinghouse speed reducers—Types SH and DH—for drives up to 1,000 hp with speed reduction ratios of 2.82 to 70.5.

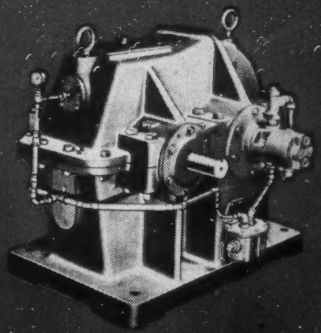
Write, wire or telephone to your nearest Westinghouse office today, for full information on the application of speed reducers to your own drives. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna.

J-07252



FOR DRIVES FROM 1 TO 75 HP CHOOSE GEARMOTORS

Within the standard listed range of 1 to 75 hp ratings, you get the best in speed reduction with Westinghouse gearmotors. Three types—A, C and E—are available and provide output speeds from 1,450 to 16.5 rpm. All unit types can be used with either single-phase, polyphase or d-c motors.



USE THESE HIGH-SPEED UNITS UP TO 2,000 HP AND 9,000 RPM

These Westinghouse Type SU units are specially designed for high-speed duty in speed increasing services for pumps, compressors and similar applications. Units are available in 30 sizes—with gear ratios from 1.25 to 3.25 up to 2 to 12.

You'll find all the facts on industrial geared drives in this new, picture-packed book. Ask for your copy of B-3730 today, on your business letterhead, please.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

4 out of 5 drives need speed reduction

TOPS for smooth,

for Bottles

REX Table Top!

● Whether your machine design problems involve the conveying of jars, bottles, cans or small parts, you'll find Rex Table Top Chain the ideal answer. Here's why!

1. Smooth, Tip-Free Conveying. Only Rex Table Top Conveyor Chain provides a constant carrying surface. There is no gap across the width of the link to catch and trip containers.

2. Simple Design. There are no attachments to loosen or "wobble" with Table Top. Precision-formed, one-piece platform links of all-stainless or case-hardened construction are connected by husky rivets. Contrast this simple design with ordinary flat-top chain.

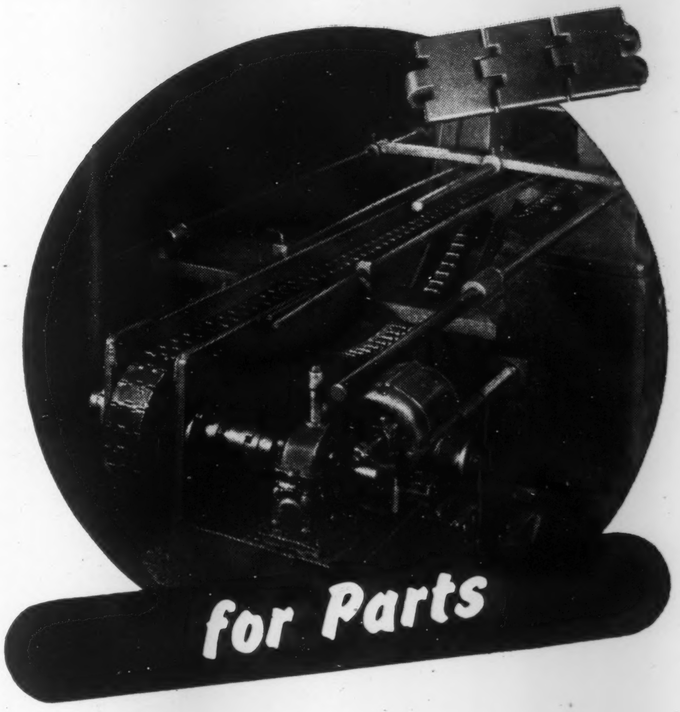
REX CHAIN BELTS

steady conveying....

3. Long Service Life. With Table Top, the entire link absorbs the pulling load. Sprocket tooth bearing pressure is spread over the entire length of the joint . . . not concentrated on a small area. Table Top just has to last longer.

4. Stays Cleaner . . . and is easy to clean. There are no pockets on Table Top to catch and hold foreign matter. It can be easily cleaned when necessary with a jet of water or steam.

The Rex Man will be glad to assist you in the application of Table Top to your designs. For all the facts and for engineering assistance, call him or write direct to Chain Belt Company, 1643 West Bruce Street, Milwaukee 4, Wis.



CHAIN BELT COMPANY
of Milwaukee . . . . .

SPEEDAIRE
CLEVELAND

As the white outline indicates, a standard unit of nearly twice the frame size would be required to do the work of Speedaire.

$330 saving...with SPEEDAIRE

IN this Michigan chemical plant, Speedaire is doing a highly satisfactory job on pan conveyors handling limestone. Reducers run cool under heavy loads, unaffected by the lime dust. Their compactness permitted a closer hookup between machines and motors, saving valuable floor space. And compared to conventional worm-gear reducers, Speedaire saved the company $330 per unit installed.

Speedaire is Cleveland's new fan-cooled worm-gear speed reducer. Because it is fan-cooled, Speedaire will do more work—will deliver up to *double the horsepower* of standard worm units of equal frame size, at usual motor speeds. It can be installed economically on many applications where other types have been used heretofore—giving you the advantages of a compact right-angle drive. Speedaire gives the same long, trouble-free service characteristic of all Clevelands.

For full description, send for Catalog 300. The Cleveland Worm & Gear Company, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

To eliminate vibration...

GISHOLT DYNETRIC* BALANCERS

Locate and measure the cause, for quick and easy correction of unbalance

Whatever it is—if it rotates, it can be balanced by a Gisholt Dynetric Balancing Machine.

Using electronic means of amplification, the Dynetric picks up unbalance vibrations as small as .000025″, locates the source and measures the amount of unbalance by a simple meter indication—all in a matter of seconds.

For the balancing of many parts such as brake drums, cream separator bowls, flywheels, etc., the vertical Type S Dynetric Balancer, shown above, provides utmost ease in mounting and removing work for volume production. It is one of many sizes and types which handle parts weighing from a fraction of an ounce to many tons.

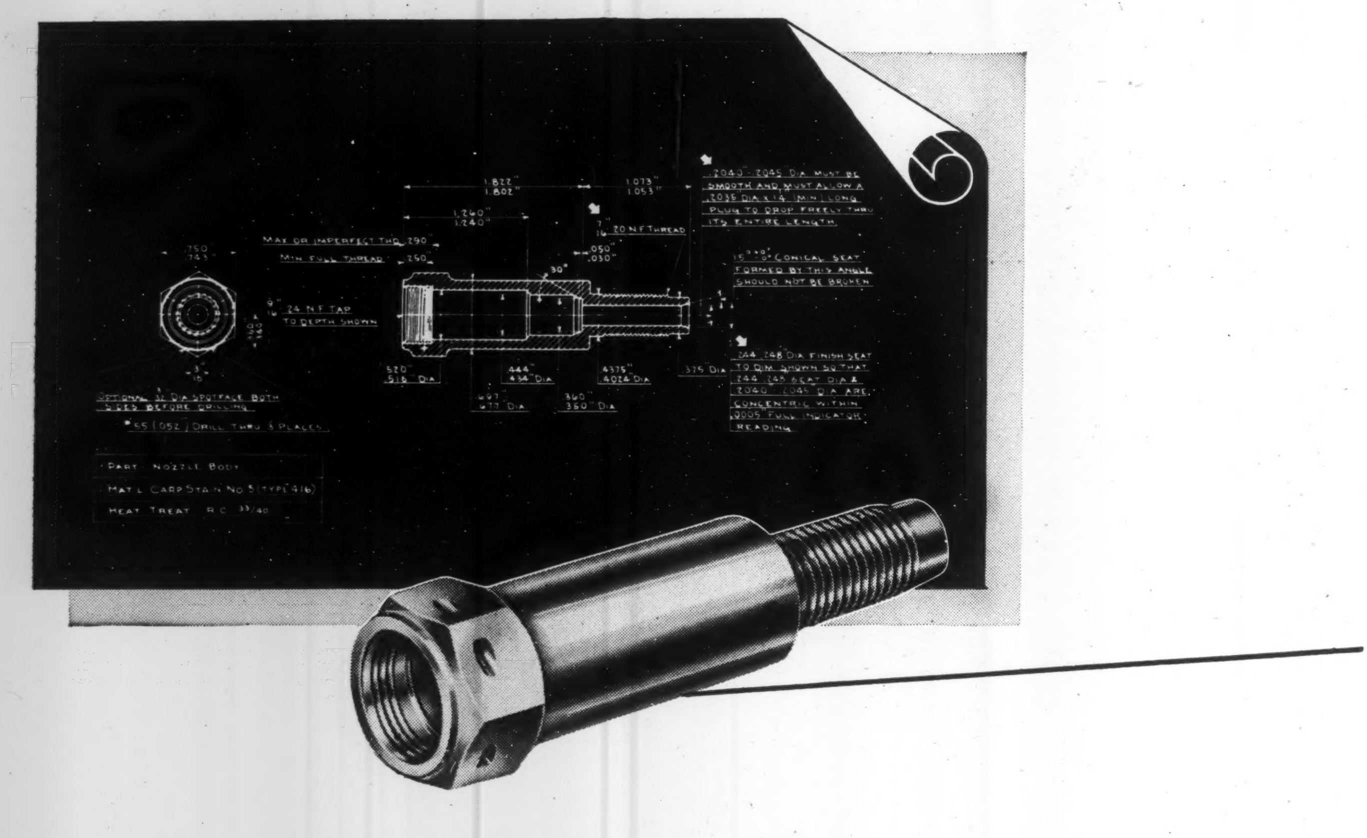
If your product can be improved by eliminating vibration, a Gisholt Dynetric will provide the quickest, most accurate means known for checking and removing the cause—*unbalance.*

**Developed jointly with Westinghouse Electric Corporation.*

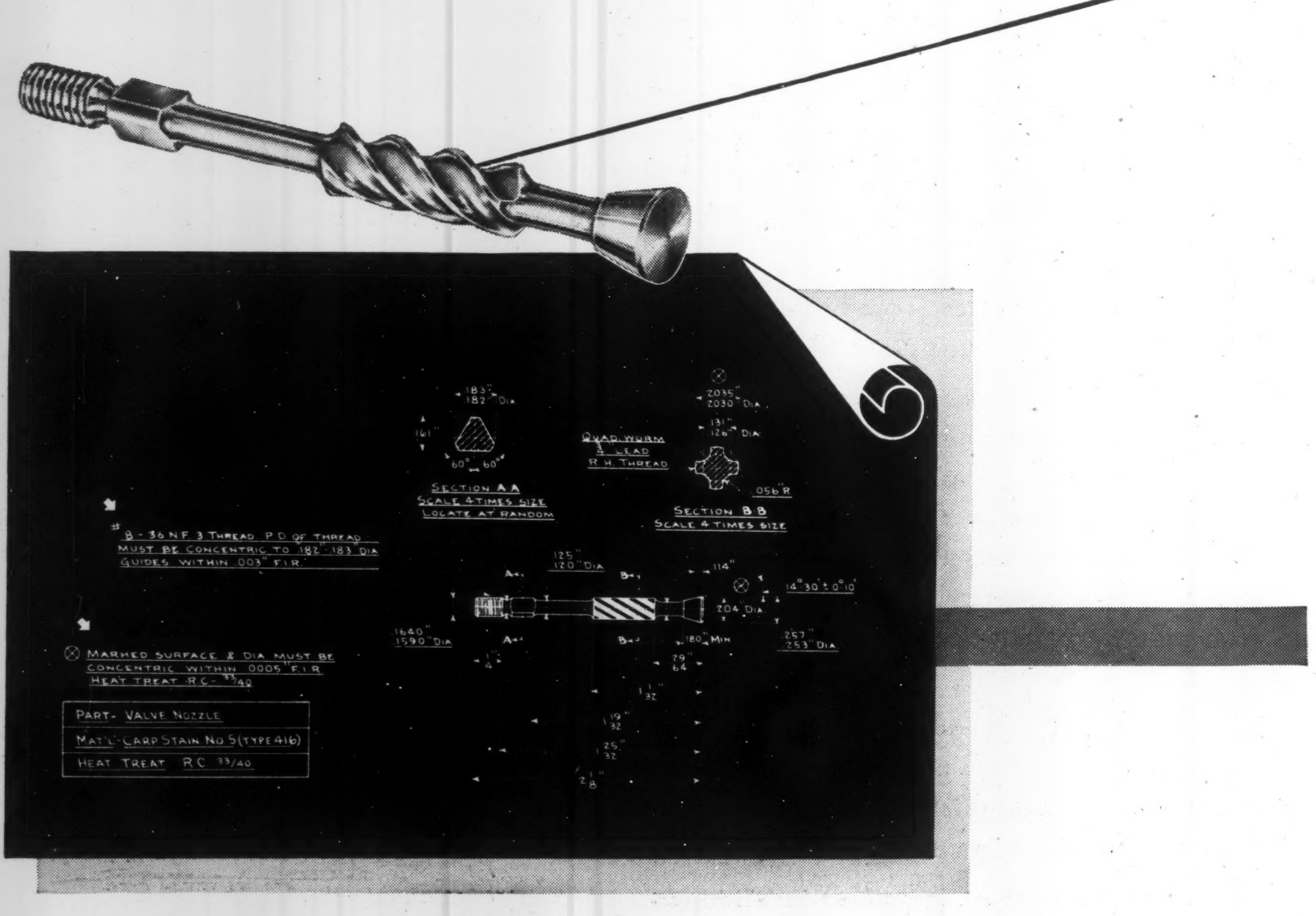
GISHOLT MACHINE COMPANY
1245 E. Washington Avenue • Madison 3, Wisconsin

THE GISHOLT ROUND TABLE *represents the collective experience of leading specialists in the machining, surface finishing and balancing of round and semi-round parts. Your problems are welcomed here.*

TURRET LATHES • AUTOMATIC LATHES • BALANCERS • SUPERFINISHERS • SPECIAL MACHINES


1.822"
1.802"
1.073"
1.053"
1.260"
1.240"
MAX OR IMPERFECT THD .290"
MIN FULL THREAD .250"
.750"
.743"
9/16 - 24 N.F. TAP TO DEPTH SHOWN
7/16 - 20 N.F. THREAD
.050"
.030"
30°
.2040"-.2045" DIA MUST BE SMOOTH AND MUST ALLOW A .2035 DIA x 1/4 (MIN) LONG PLUG TO DROP FREELY THRU ITS ENTIRE LENGTH
15° +0° -0° CONICAL SEAT FORMED BY THIS ANGLE SHOULD NOT BE BROKEN
.244-.248" DIA FINISH SEAT TO DIM SHOWN SO THAT .244-.248 SEAT DIA & .2040"-.2045" DIA ARE CONCENTRIC WITHIN .0005" FULL INDICATOR READING
.520" .516" DIA
.444" .434" DIA
.4375" .4024" DIA
.375" DIA
.697" .677" DIA
.360" .360" DIA
3/16
OPTIONAL 3/32 DIA SPOTFACE BOTH SIDES BEFORE DRILLING
#55 (.052) DRILL THRU 3 PLACES
PART NOZZLE BODY
MAT'L CARP STAIN NO 5 (TYPE 416)
HEAT TREAT R.C. 33/40

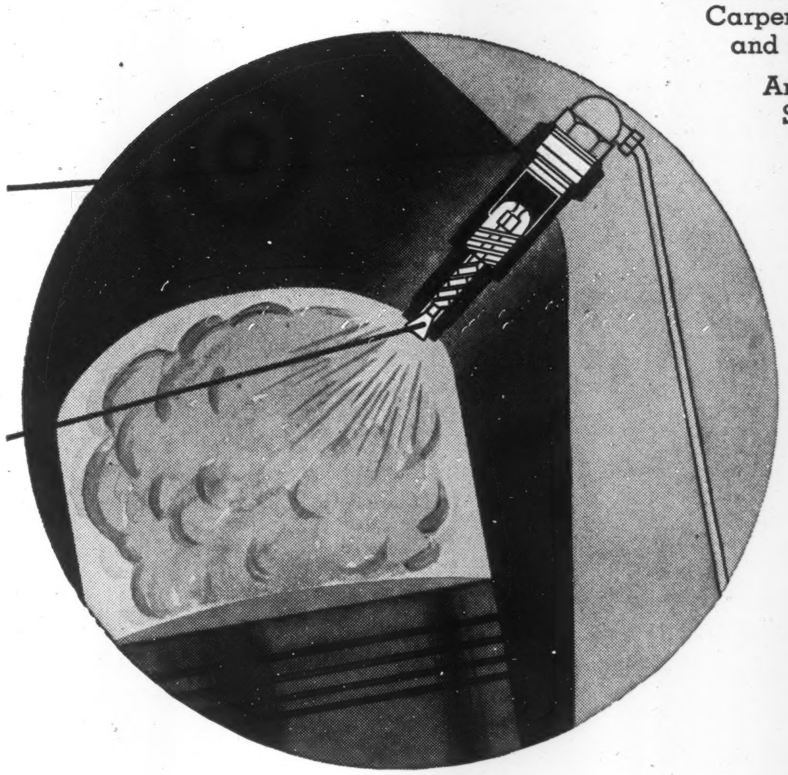
You really begin to cut machining costs when your orders specify *Carpenter* Free-Machining Stainless for precision jobs like these aircraft fuel injector parts.


.183"
.182" DIA
.161"
60° 60°
SECTION A-A
SCALE 4 TIMES SIZE
LOCATE AT RANDOM
QUAD WORM 1/4 LEAD R.H. THREAD
.2035"
.2030" DIA
.131"
.126" DIA
.056"R
SECTION B-B
SCALE 4 TIMES SIZE
# 8-36 N.F. 3 THREAD. P.D. OF THREAD MUST BE CONCENTRIC TO .182"-.183" DIA GUIDES WITHIN .003" F.I.R.
.125"
.120" DIA
.114"
14°30' ± 0°10'
.204" DIA
.1640"
.1590" DIA
.180" MIN
.257"
.253" DIA
1/4
29/64
1 1/32
1 19/32
1 25/32
2 1/8
A A B B
⊗ MARKED SURFACE & DIA MUST BE CONCENTRIC WITHIN .0005" F.I.R.
HEAT TREAT R.C. 33/40
PART- VALVE NOZZLE
MAT'L-CARP STAIN NO 5 (TYPE 416)
HEAT TREAT R.C. 33/40

How to Get the Most from Stainless
and Reduce Your Unit Costs!

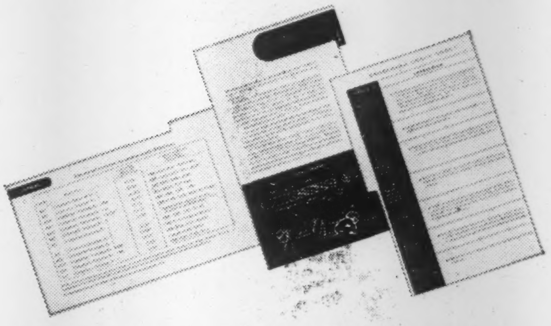
Right now when you are looking for new ways to cut costs, take a look at your Stainless fabricating picture. For true economy, you need the right analysis of Stainless Steel for the job.

But *more* than that, you need a Stainless that is so uniform from lot to lot that you can rely upon it to respond to the same machining methods *every* time. That's why cost-minded designers and production men prefer Carpenter Stainless. Its uniformity—saves time and trouble—keeps down rejects.



Another big advantage of using Carpenter Stainless is the Carpenter experience you get along with it. Personal help and cooperation from your Carpenter representative, plus helpful printed information make it easy to get the most out of these Stainless Steels. For fast delivery on Stainless bars, call your nearby Carpenter warehouse.

Here's the First Step to Lower Costs on Stainless Jobs



Your Carpenter representative has copies of this cost-reducing information available for management and production executives. The 96-page "Notebook on Machining Stainless Steels" will help you discover new ways to reduce your unit costs on Stainless jobs. Extra copies of this valuable book can also be supplied as a guide to the men in your shop, at 50¢ per copy. Write us, on your company letterhead, please.

THE CARPENTER STEEL COMPANY • 120 W. BERN STREET, READING, PA.

Carpenter

FREE-MACHINING

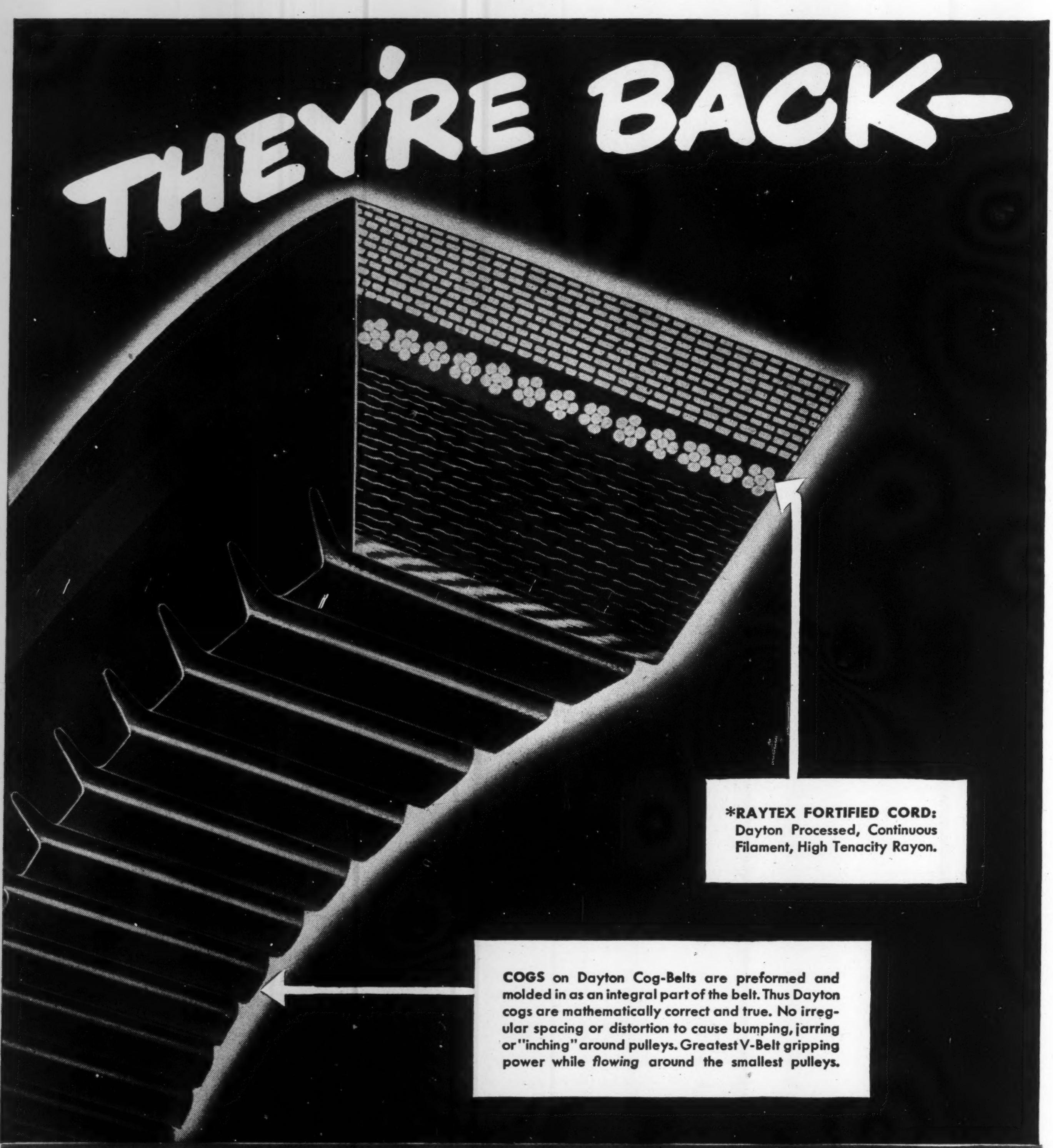
STAINLESS STEELS

more than corrosion resistance

PROMPT SHIPMENT FROM CONVENIENTLY LOCATED STOCKS

Buffalo
Chicago
Cincinnati
Cleveland
Dayton
Detroit
Hartford
Indianapolis
New York
Philadelphia
Providence
St. Louis

SEE THE CLASSIFIED SECTION OF YOUR TELEPHONE DIRECTORY


THEY'RE BACK—

***RAYTEX FORTIFIED CORD:**
Dayton Processed, Continuous Filament, High Tenacity Rayon.

COGS on Dayton Cog-Belts are preformed and molded in as an integral part of the belt. Thus Dayton cogs are mathematically correct and true. No irregular spacing or distortion to cause bumping, jarring or "inching" around pulleys. Greatest V-Belt gripping power while *flowing* around the smallest pulleys.

Dayton

THE MARK OF TECHNICAL

THE WORLD'S LARGEST

DAYTON COG-BELTS

The Premium V-Belt

Built specifically for use on drives demanding maximum compactness with smallest possible pulleys . . . shortest centers

Yes, they're here . . . the new, premium Dayton Cog-Belts, successor to the famous Dayton Cog-Belts that made power transmission history on the toughest industrial drives in the United States and twenty-seven foreign countries.

Incorporating all the features of the original Dayton Cog-Belt, this new premium V-Belt offers additional advantages gained by the use of war-born materials and developments . . . including *Raytex Fortified Rayon Cords . . . cords that practically eliminate belt stretch, that provide greater flex strength and greatly increased V-Belt life . . . on the smallest pulleys.

The new Dayton Cog-Belt is a premium V-Belt designed and built especially for V-to-V or V-Flat drives that demand:

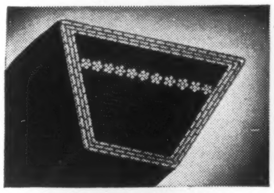
SMALLER PULLEYS—Because of their exclusive preformed and true cog construction with die-cut sides, Dayton Cog-Belts *flow* easily, naturally, around substandard pulleys while providing undistorted maximum contact arc.

SHORTER CENTERS—Because smaller pulleys can be used, the distance between the motor and driven machine can also be shortened with proper V-Belt contact arc.

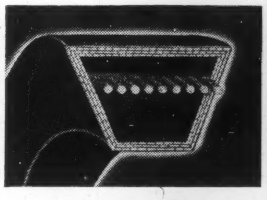
The new Dayton Cog-Belt is now in production in many sizes. It is a premium belt at a premium price, built especially for use on drives where maximum compactness with smallest pulleys and shortest centers is essential. For complete information, call . . .

DAYTON RUBBER • DAYTON, OHIO
Branch Offices: Atlanta • Boston • Chicago • Cincinnati Cleveland • Dallas • Dayton • Detroit • Los Angeles Minneapolis • New York • Philadelphia • St. Louis

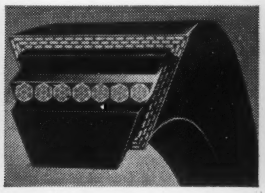
A COMPLETE V-BELT LINE FOR EVERY POWER NEED



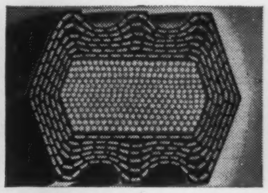
DAYTON THOROBRED V-BELT. For the millions of industrial applications using regular pulley diameters.



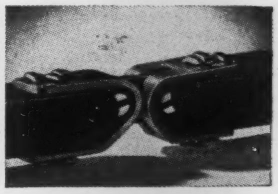
DAYTON STEEL CABLE V-BELT. For those unusual power transmission jobs that demand maximum pull.



DAYTON O-H-S V-BELT. For drives where extreme conditions of Oil, Heat and Static are present.



DAYTON DOUBLE ANGLE V-BELT. Where power needs must be taken from both sides of the belt.



CONNECTOR TYPE V-BELT. Permits V-Belt advantages where endless V-Belts cannot be applied.

Dayton Rubber

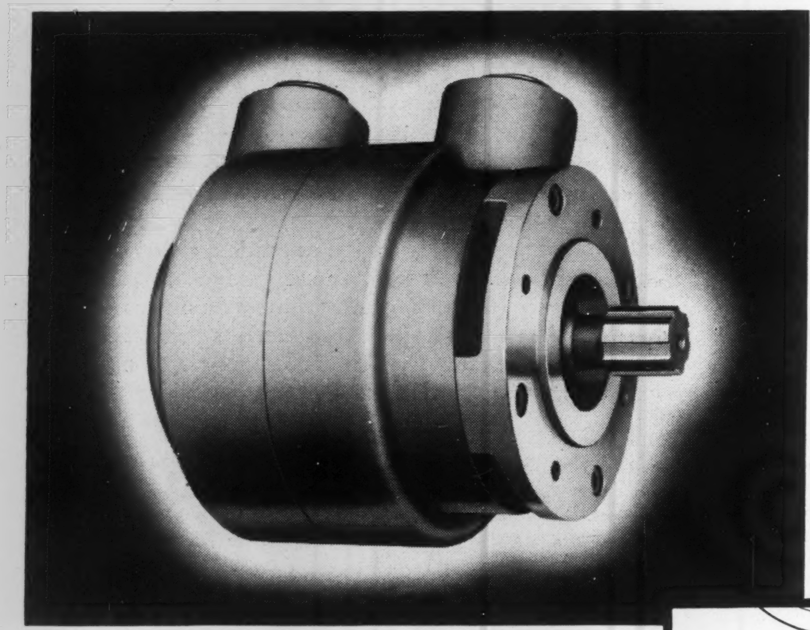
EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

MANUFACTURER OF V-BELTS

Announcing . . .

A NEW ACHIEVEMENT IN ROTARY POWER TRANSMISSION

DUDCO VANE-TYPE FLUID MOTOR



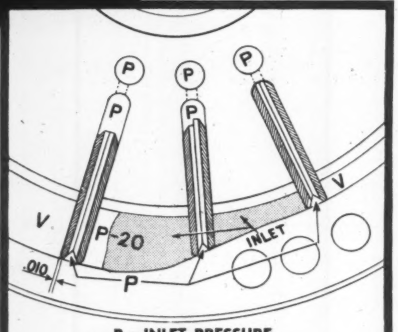
Proven **IN 5 YEARS OPERATION TO HAVE**

Highest Torques at Low Pressures

Lowest Speeds without Gearing

YET . . .

- √ Smaller In Size for Rating
- √ Lower In Price
- √ Simpler In Design—Easily Maintained—Rugged



P = INLET PRESSURE
V = OUTLET PRESSURE

Sealing of vanes against rings effected by .010-inch chamfer. At 1000 P.S.I. sealing force equal to 10 pounds.

CHECK THESE FEATURES!

- 3 R.P.M. (smooth) without gear box, with torques to 1000 lb. in.
- Stall torque 90% theoretical at all positions of shaft
- Torques from 75 lb. in. to 250 lb. in. per 100 P.S.I.
- Size is 7½ in. diameter x 8½ in. long
- Mechanical efficiency (overall) 77% at 100 R.P.M.
- 28 H.P. at 450 R.P.M., 1500 P.S.I., 40 gal. per min.
- Maintenance problem can be handled by shop mechanic
- Adaptable to applications requiring revolving nut or automatic declutching of shaft from motor
- Hydraulically balanced—no cams or wear plates to transmit longitudinal motion to radial motion

Get Complete Information

Send now for folder on the Dudco Vane-Type Fluid Motor giving full details of construction and performance. Write on your company letterhead.

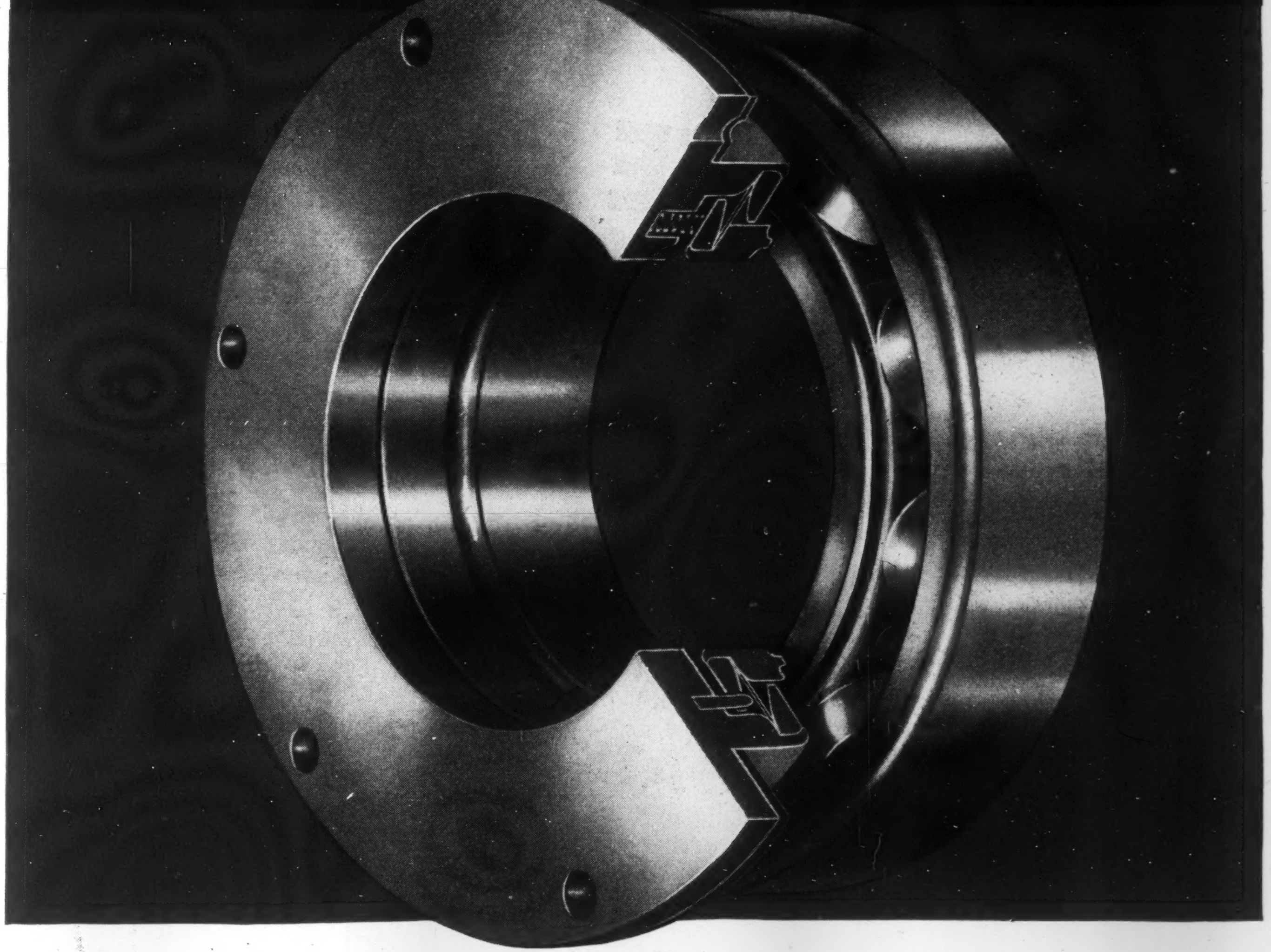
DUDCO VANE-TYPE FLUID MOTORS—THE PERFECT ANSWER TO ALMOST ALL YOUR ROTARY POWER REQUIREMENTS

DETROIT UNIVERSAL DUPLICATOR COMPANY
18100 RYAN ROAD DETROIT 12, MICHIGAN

TRUE RUNNING for POSITIVE SEALING

GITS

HIGH SPEED OILSEALS



Flanged or Press-Fit Styles for Vertical or Horizontal Application

For complete information on this and the complete GITS line of lubricating devices—write for bulletin.

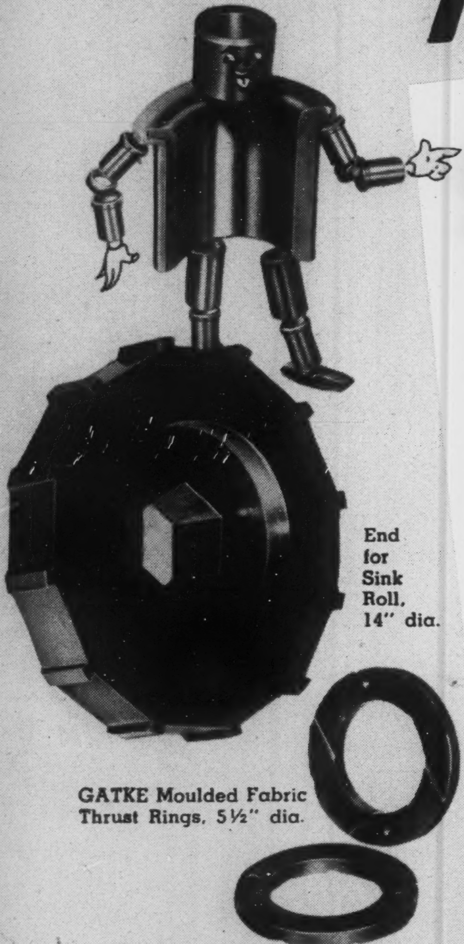
With highly-finished, specially-tensioned bronze contact face, Gits Seals operate on bearing race or true-running, ultra-hardened and lapped washer. Seal does not contact periphery of shaft. Properly even pressure is assured by steel springs. Oilproof and waterproof diaphragm resists 200° F. continuous heat. Torsional strain on diaphragm is eliminated by guide pins. Available in ¼″ to 4″ shaft diameters —larger on application. Submit your specifications to us for recommendations.

GITS BROS. MFG. CO.

1868 South Kilbourn Avenue, Chicago 23, Illinois

Exclusive for over 35 years

Bearing Problems?



End for Sink Roll, 14" dia.

GATKE Moulded Fabric Thrust Rings, 5½" dia.

SEE GATKE

GATKE Bearings are effecting wonderful economies on all sorts of troublesome applications where short life, production delays and costly up-keep are accepted as unavoidable with conventional bearings.

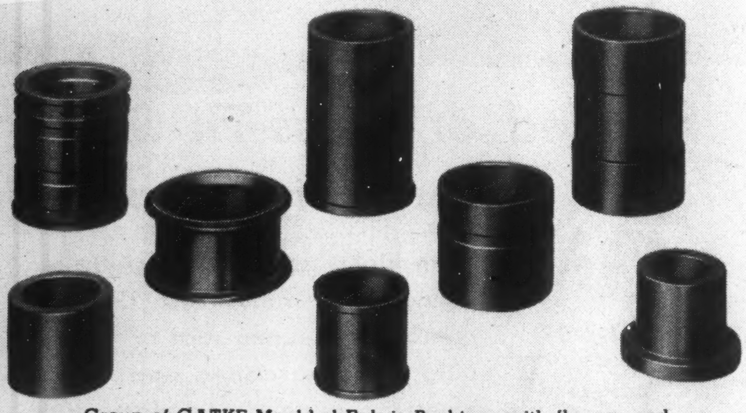
The extraordinary performance results from qualities not obtainable in metal bearings — performance qualities made possible by GATKE Processes of moulding select fabric materials to finished dimensions under heat and tremendous pressures.

Tremendous impact strength with resilience to absorb shock and dampen vibration, extraordinary grease-retaining qualities, freedom from scoring and corrosion are but a few of the many important advantages.

Whatever the service—however difficult or unusual—send data for the GATKE Recommendation or write for literature.

GATKE CORPORATION
252 N. LaSalle St., Chicago 1, Ill.

GATKE Bearings used on Rubber Mills. Reports show 10 years of perfect operation where conventional bearings had been a constant source of trouble and expense.



Group of GATKE Moulded Fabric Bushings with flanges and other external shapes. Sizes range from 2½" to 5" dia.

Gatke MOULDED FABRIC BEARINGS

vibration protection with teeth in it!

There's no locking principle that can match the tapered-twisted teeth of the Shakeproof Lock Washer for positive protection against the loosening action of vibration. Whether you're using a large size to anchor a motor block or a small size to assemble a delicate instrument you'll find that Shakeproof's exclusive teeth bite into both surfaces and set up a strut-action lock that prevents the screw or nut from working loose. Vibration protection like this is the result of constant research . . . the kind of research that has produced Shakeproof's newest lock washer which is available now in some of the smaller sizes. This new lock washer has a greater number of teeth which provide an increased tooth area for still better locking. With more metal at the rim, resistance to flattening is increased and breakage is virtually eliminated. In short, it's our famous tapered-twisted principle applied in such a way that you get more teeth, more locking edges.

SHAKEPROOF
LOCK WASHERS

SHAKEPROOF, INC.
Division of Illinois Tool Works
2501 North Keeler Avenue, Chicago 39, Illinois
2895 E. GRAND BLVD., DETROIT 2, MICH.
OFFICES IN OTHER PRINCIPAL CITIES
In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario

Men, Materials and When REEVES Speed

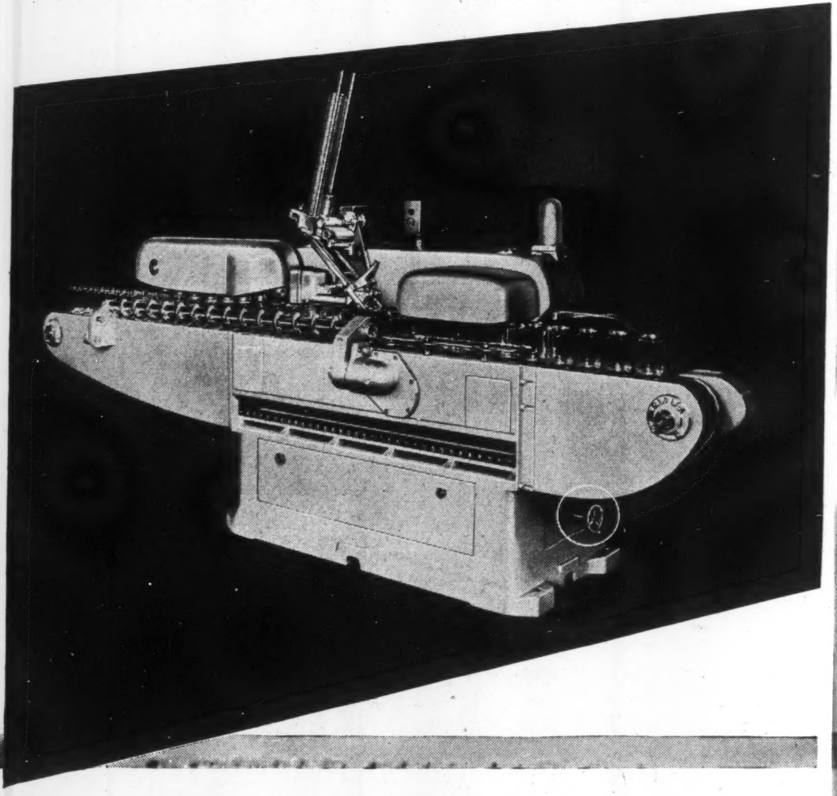
REEVES
SPEED
CONTROL

The increased economy and efficiency which your customers expect from the new machines you build cannot be achieved by *higher machine speed alone.* For the fastest moving mechanism in the world can be a white elephant on the production line if its speed is not properly co-ordinated and accurately synchronized with the action of those two other vital production factors—*men and materials.*

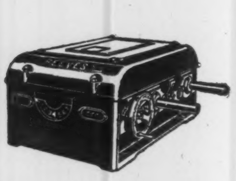
With accurate, infinite REEVES Speed Control on the job, men, materials and machines *act as one* . . . for the REEVES-equipped machine can be instantly adjusted—without stopping—to work at the speed best suited to the skill of the operator and the characteristics of the material. With this kind of teamwork, it's easy to understand why the addition of REEVES is invariably followed by greater output and improved, uniform quality at lower cost.

So why not do as the manufacturers of 2,100 different makes of machines have already done? Make REEVES Speed Control standard equipment on *your* machines. An experienced REEVES field engineer will be glad to consult with you on application and engineering details, and acquaint you with the wide range of sizes, capacities, speed ratios and controls in which the complete REEVES line is available. You'll also probably want a copy of the comprehensive, 96-page catalog describing all REEVES units in detail. Just write for H-450.

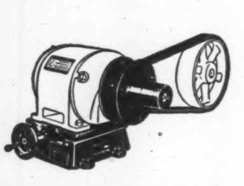
The Anchor Steriseal Machine, product of Anchor Hocking Glass Corporation, Lancaster, Ohio, is an automatic straight-line steam vacuum capping machine designed for high speed application of AH-N Caps on glass containers. By means of a REEVES Vari-Speed Motor Pulley, which is furnished as standard equipment, the Steriseal can instantly and accurately provide any commercial speed that may be required on packers' production lines.



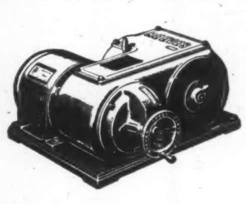
THE THREE BASIC REEVES SPEED CONTROL UNITS



VARIABLE SPEED TRANSMISSION for providing infinite, accurate speed flexibility over a wide range—2:1 to 16:1. Sizes—fractional to 87 hp.



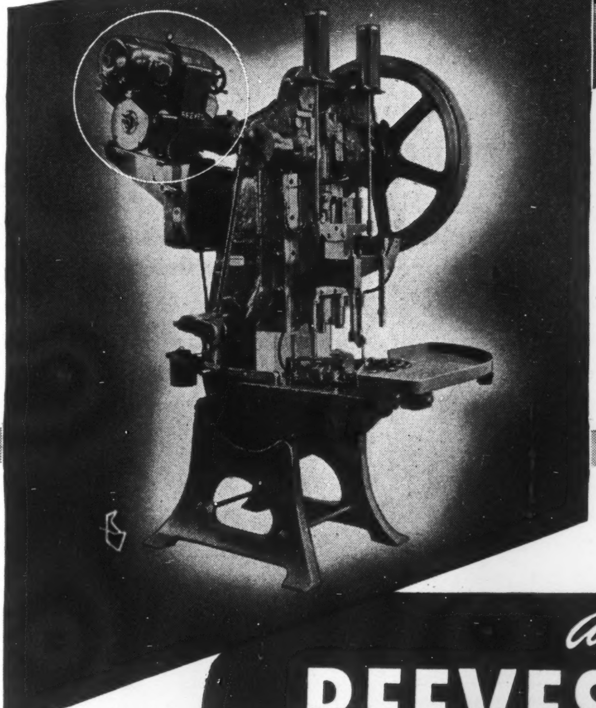
VARI SPEED MOTOR PULLEY converts any standard constant speed motor to a variable speed drive within 4:1 ratio. Sizes to 15 hp.

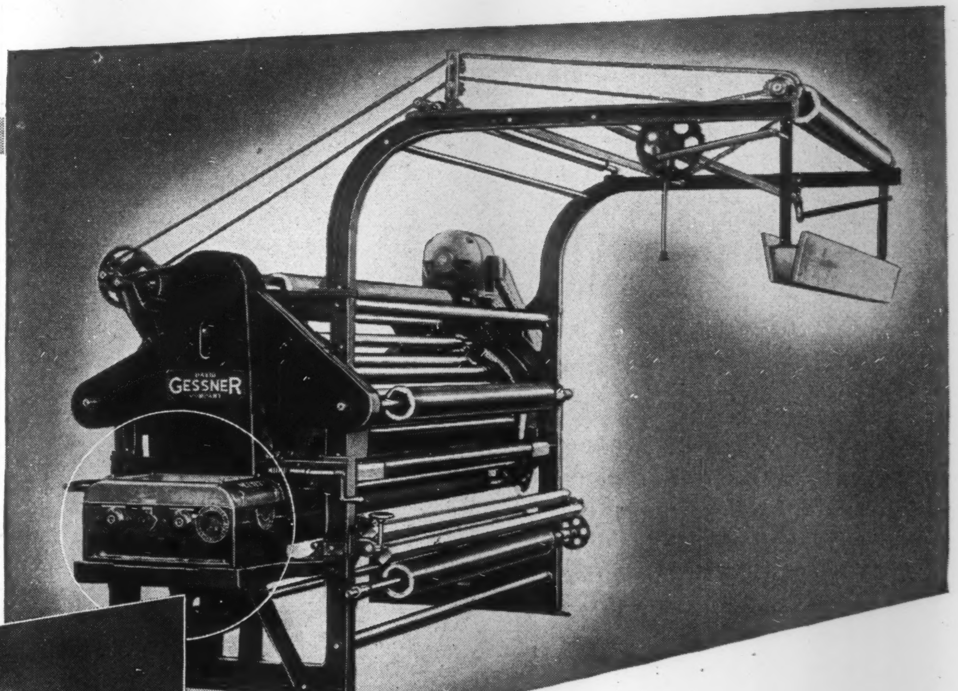


MOTODRIVE combines motor, speed varying mechanism and reduction gears in single compact unit. Speed variations 2:1 to 6:1 Inclusive. Sizes to 15 hp.

Machines Act As One Control Is on the Job

This Plain Reducing Press, built by The V & O Press Company, Hudson, N. Y., is used for piercing, notching and extruding condensor tins. The REEVES Motodrive, with which the press is standardly equipped, instantly and accurately provides the right speed for each operation. By turning the convenient REEVES handwheel, the operator can obtain any speed within the machine's range of 378 to 756 rpm.





In this Single Acting Napper, manufactured by David Gessner Co., Worcester, Mass., a horizontal, enclosed-type REEVES Variable Speed Transmission, which is standard equipment on all machines of this model, provides infinite speed adjustability to permit instant and accurate control of the amount of pile raised.

REEVES PULLEY COMPANY · COLUMBUS, INDIANA

Recognized Leader in the Specialized Field of Speed Control Engineering

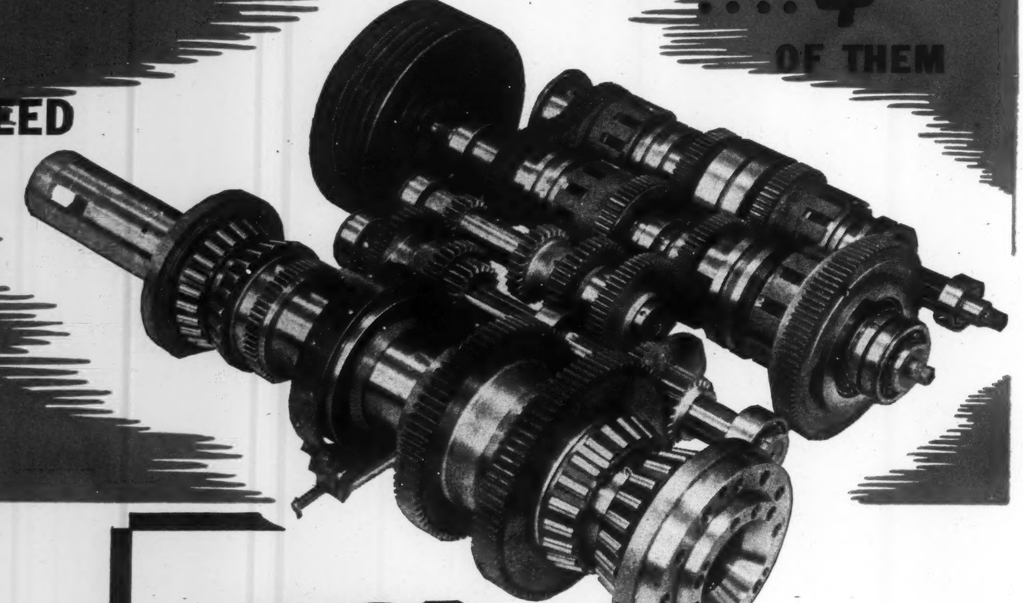
Accurate Variable

REEVES Speed Control

Gives the Right Speed for Every Job!

MAXITORQ CLUTCHES . . . . 4 OF THEM

control **SPINDLE SPEED SHIFTS ON THIS MACHINE TOOL**



Naturally we are highly gratified to see many leading machine tool manufacturers installing MAXITORQ Floating Disc CLUTCHES in their control sections. And, as we believe you too will be interested in seeing some of these applications, we are showing this month, how one designer uses our hydraulically-operated clutches (4 of them) for quick forward and reverse and low-high shifts in the ratio of 6:1 . . . a valuable feature in drilling-tapping, boring-reaming and turning-threading operations. There are several ways that spindle speed shifts can be made but this one has proven superior in this application . . . and it might well be true in other types of controls.

Here are some of the reasons for the wide-spread acceptance of Maxitorq:

1. Separator Springs which hold the discs apart in neutral, preventing drag, abrasion and heating.
2. Locking Plate which locks all discs against tension developed by the Separator Springs.
3. Manual Assembly, Adjustment and Take-apart . . . without the use of tools.
4. Quick, positive disconnect . . . no slipping from neutral.
5. Clutch is completely assembled on the clutch body . . . shipped ready to slip on a shaft.

These, and other features are the result of our more than 40 years of building clutches *only*. They are also included, with additional refinements, in our new Maxitorq Automatic Overload Release Clutch, especially designed for high speed machinery which processes damageable or breakable products.

May we suggest that you investigate Maxitorq Clutches. They may be the answer to your power transmission problems.

Send for Catalog No. MD4

Let's talk
MAXITORQ

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

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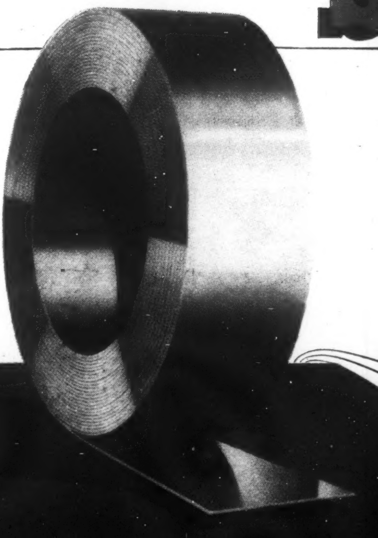
Beautifully Stainless...

and easier to make, with

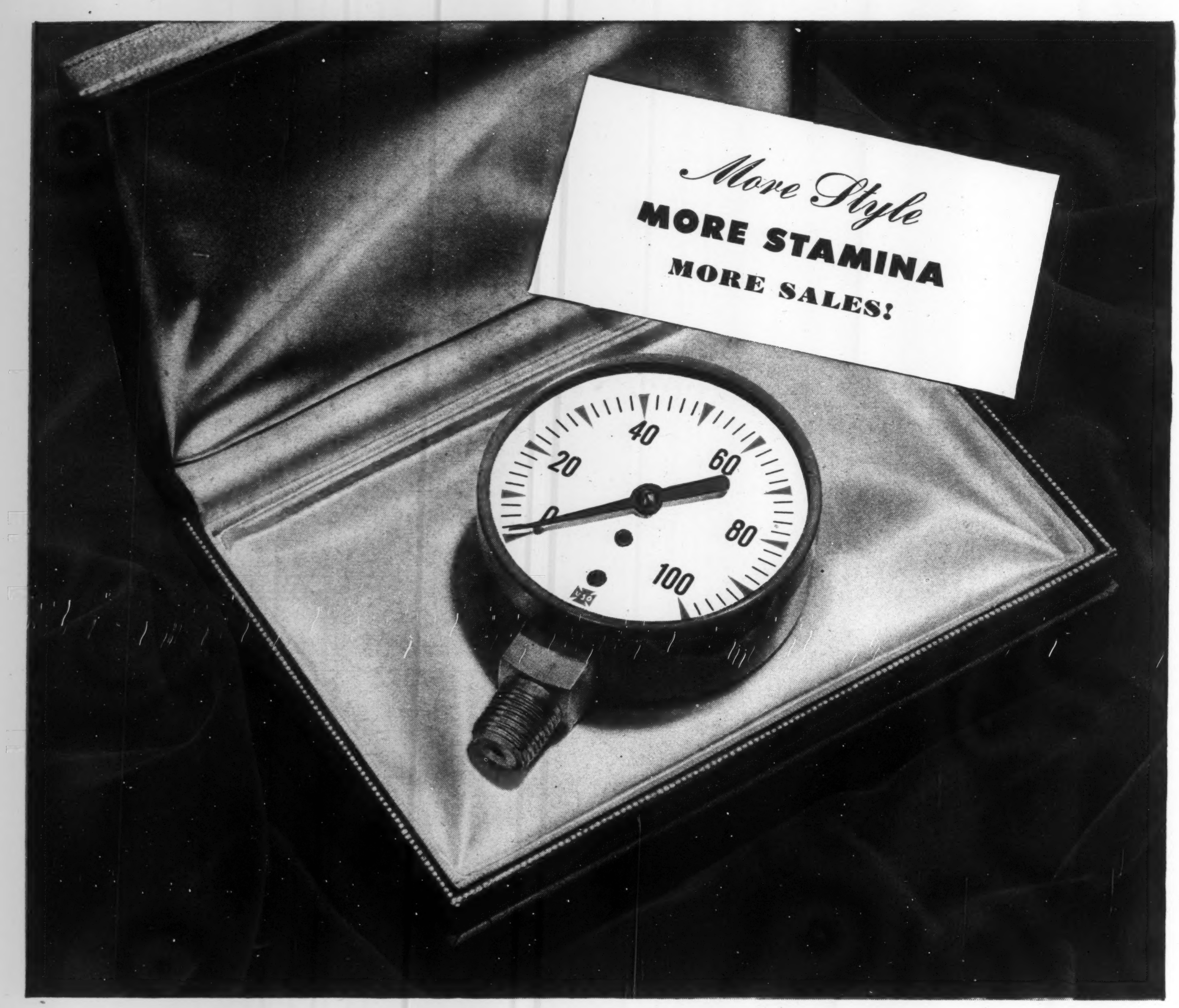
Superior STAINLESS STRIP STEEL



Modern tableware . . . cutlery . . . kitchen tools . . . all providing *beauty in service* for the consumer, and *ease of fabrication* for the manufacturer . . . made of SUPERIOR Stainless Strip Steel!

Superior Stainless behaves well for the fabricator because it's a specialized product. We're specialists in strip steels, and we give special care to the control of stainless quality in grades, tempers, dimensions and finishes. Your work is speeded when you use Superior Stainless. Send us your specifications—or let us give you an experienced recommendation!

Superior Steel


More Style
MORE STAMINA
MORE SALES!
20
40
60
80
100
0

1000
1500
2000
500
2500
0
3000
U.S. INSTRUMENTS Tell The Truth

YES, THIS NEW LINE OF U.S.G. gauges is three ways ahead. It's way out in front in appearance, styled by top American designers. It's improved inside to lengthen life yet retain famous U S G accuracy. It's a line of gauges that will make your product look even better and sell faster.

UNITED STATES GAUGE, SELLERSVILLE, PA.

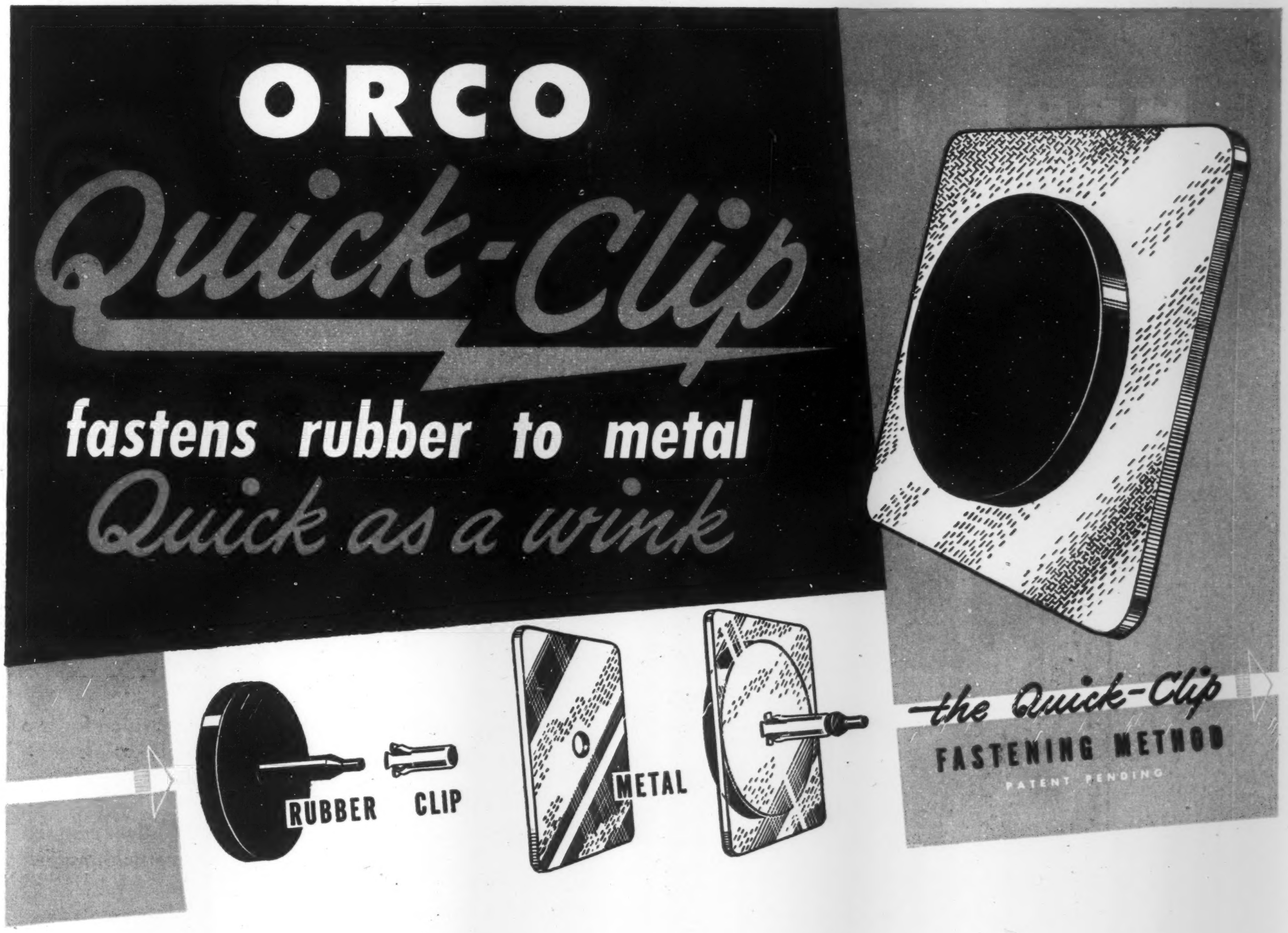
USG

UNITED STATES GAUGE

DIVISION OF AMERICAN MACHINE AND METALS, INC.

Manufacturers of Pressure, Temperature, Flow and Electrical Measuring Instruments

ORCO
Quick-Clip
fastens rubber to metal *Quick as a wink*



"Quick as a wink" is the way rubber is locked to metal with the ORCO *Quick-Clip* method of fastening.

Note the integral stem on the molded rubber part. The stem goes through a hole drilled in the metal. A metal clip slips over the rubber stem. Presto! The rubber part is fastened to the metal *permanently*. (No tools needed.)

The number and position of stems on a molded rubber part are dependent upon the size, shape and other factors relating to the specific rubber and metal parts to be fastened. Likewise, the design, size, and shape of the metal clip is subject to numerous variations to meet specific conditions.

Furthermore, the ORCO *Quick-Clip* method is not restricted to molded rubber parts. Under certain conditions, the method has practical application to extruded rubber parts.

Speed of application and permanency of fastening rubber to metal are two chief advantages of the ORCO *Quick-Clip* method.

Although numerous conditions still call for the usual ORCO rubber-to-metal bonding processes, the new ORCO *Quick-Clip* method extends the scope of rubber-to-metal applications.

Inquiries for further information are invited but present conditions make it impossible to make definite delivery commitments.

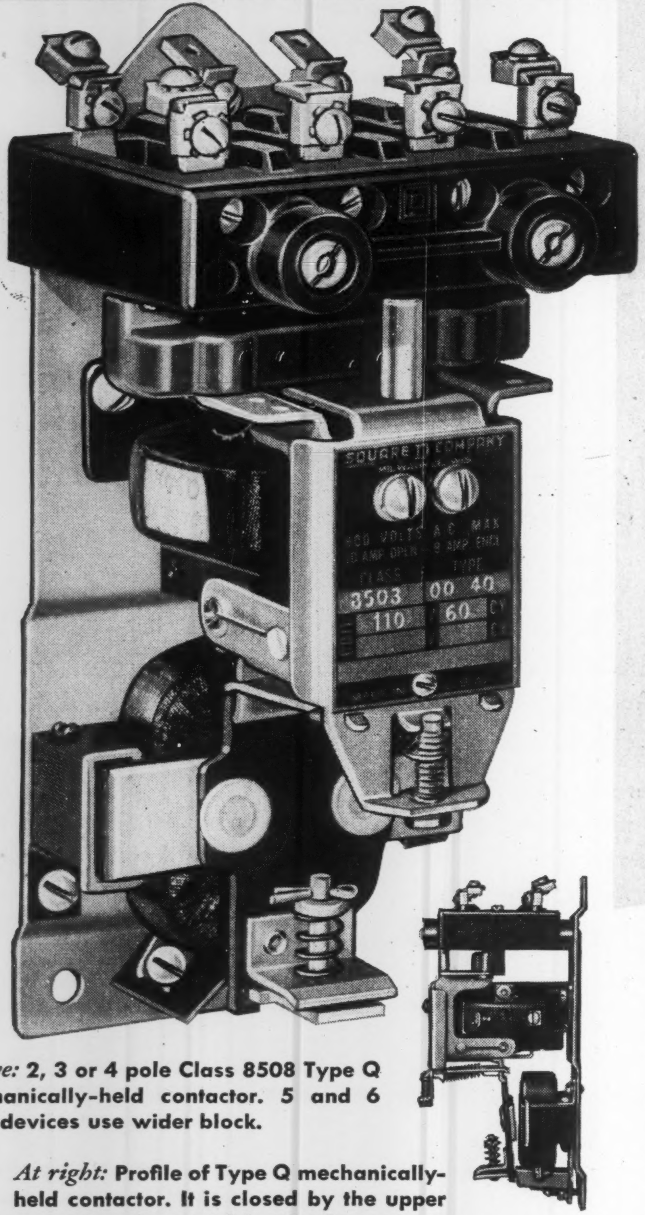
THE OHIO RUBBER COMPANY
Orco-operation
WILLOUGHBY OHIO

Factories: WILLOUGHBY, OHIO • LONG BEACH, CAL. • CONNEAUTVILLE, PA.

Branch Offices: DETROIT • NEW YORK • CHICAGO • INDIANAPOLIS • CLEVELAND • BOSTON

HERE IS A MECHANICALLY

that's built like a



Above: 2, 3 or 4 pole Class 8508 Type Q mechanically-held contactor. 5 and 6 pole devices use wider block.

At right: Profile of Type Q mechanically-held contactor. It is closed by the upper magnet and opened by the lower one.

OFFERS THE SAME DESIGN AND CONSTRUCTION FEATURES AS THE CLASS 8502 TYPE Q MAGNETIC CONTACTORS

CONVERTIBLE CONTACTS require no additional parts for change from normally open to normally closed. Maximum flexibility.

ACCESSIBLE TERMINALS with provision for two wiring clips accommodate multiple connections characteristic of sequence control.

LONGER LIFE from double break silver contacts and a well-guided straight line, vertical magnet action.

CONTINUOUS DUTY MAGNET COILS provide greater circuit flexibility and minimize contacts required.

SMALL SIZE without any sacrifice of accessibility.

STEEL PANEL MOUNTING and front connections match other devices used for automatic control.

FULL RATINGS of 10 amperes open and 9 amperes closed at 600 volts A.C. maximum, on both normally open and normally closed contacts.

2 TO 6 POLES are available in any combination of normally open and normally closed contacts.

LOWER COST because majority of parts are in common with higher production magnetic contactors.

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

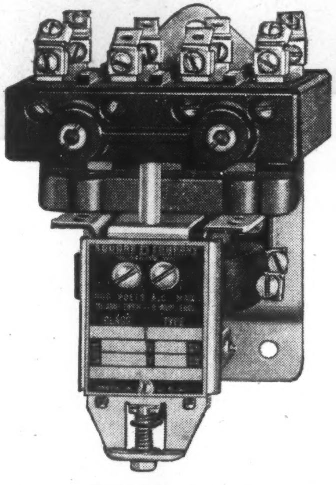
HELD SIZE OO CONTACTOR

Magnetic Contactor

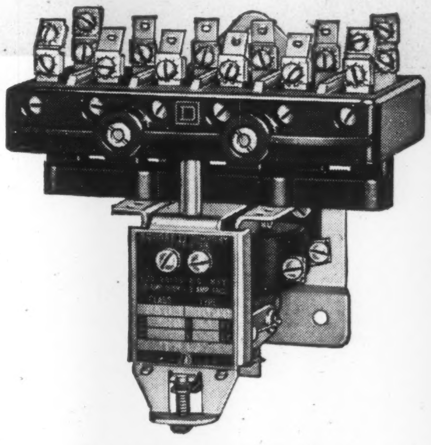
APPLICATION—Circuits based on magnetic contactors revert to the initial point in an automatic sequence if voltage fails or disconnect switch is opened. Sequence is not interrupted when mechanically-held contactors are used. Either or both kinds of contactors may be needed for various types of applications and machinery. Similar construction and operational features are desirable.

CONTACTS EASILY CONVERTIBLE from normally open to normally closed without addition of parts are illustrated in the sectional views at right. Contact pressure is the same for either arrangement, permitting both to be used to full capacity.

Stock contactors can be changed on the job, easily and quickly, to meet any requirement. Simply remove the movable contact assembly, turn it over and reassemble. No additional parts are involved.

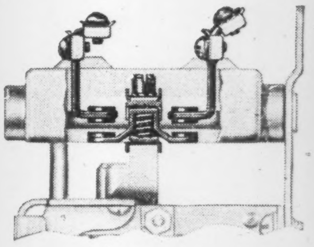


2, 3 or 4 Pole Class 8502 Type Q magnetic contactor

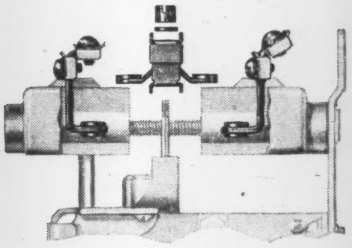


5 or 6 Pole Class 8502 Type Q magnetic contactor

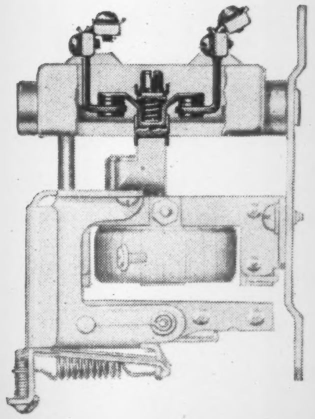
Write for Class 8502 (magnetic) and 8508 (mechanically-held) Type Q contactor price and descriptive data. SQUARE D COMPANY, *4041 N. Richards Street, Milwaukee 12, Wisconsin.*



Normally Open Contacts



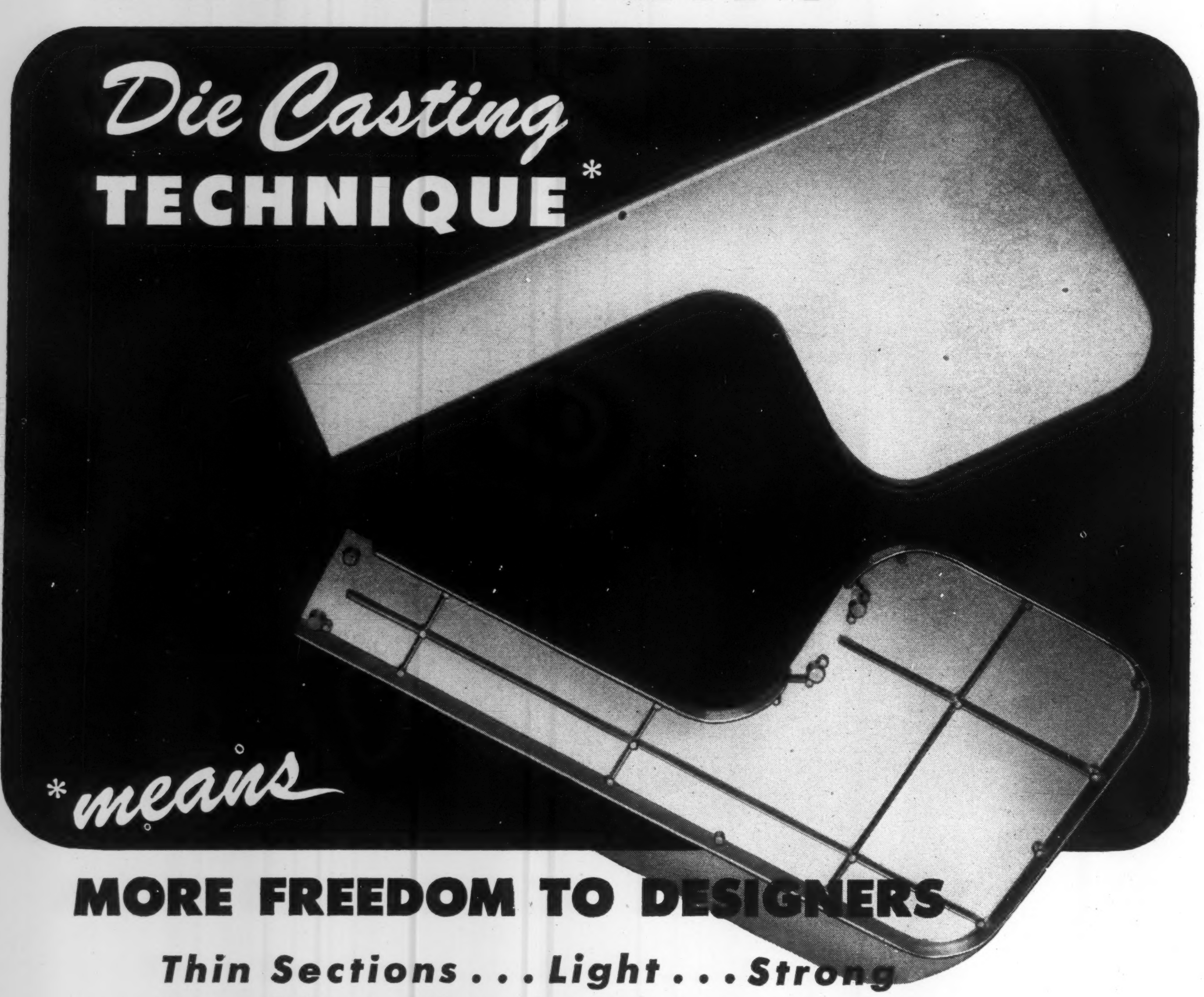
Movable Contact Assembly removed and ready to be inverted.



Normally Closed Contacts

MADISON-KIPP

Die Casting TECHNIQUE*



*means

MORE FREEDOM TO DESIGNERS

Thin Sections . . . Light . . . Strong
Durable . . . Pleasing Appearance

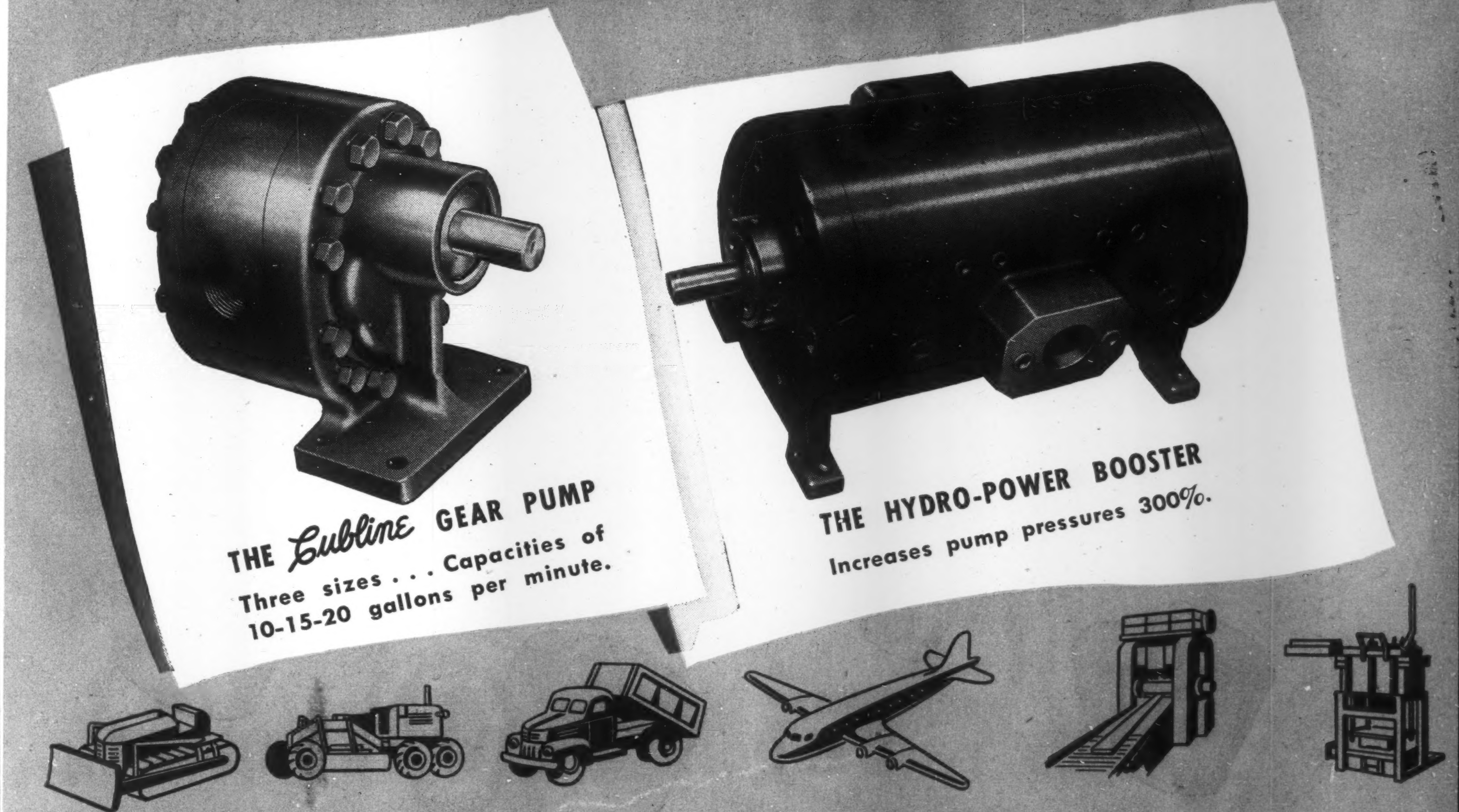
The success story of the die casting process is based on two factors, i.e., the excellence of its craftsmen — mechanics and engineers — and their restlessness. Month after month there are new developments in die casting. Month after month more designers incorporate die castings in their products . . . The aluminum ironer extension wing here illustrated is only .080″ thin, but with ribs and extended edges it has a strength ratio of many times normal load . . . For plain or intricate parts required in large quantities die castings very often offer distinct advantages.

MADISON-KIPP CORPORATION
210 WAUBESA STREET, MADISON 4, WISCONSIN, U. S. A.
ANCIENS ATELIERS GASQUY, 31 Rue du Marias, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.
WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

Two Space-Saving Units

FOR HYDRAULIC POWER SYSTEMS


THE Cubline GEAR PUMP
Three sizes . . . Capacities of 10-15-20 gallons per minute.
THE HYDRO-POWER BOOSTER
Increases pump pressures 300%.

For new installations or modernizing the old—

NEW GEAR PUMP. This new pump was designed to give you three things: first, a compact, space-saving hydraulic power unit; second, a versatile pump, fitting a multiplicity of applications; third, a sturdy, precision-built unit that can withstand tough service, at a price that removes cost objections.

NEW HYDRO-POWER BOOSTER. With this working partner of the Hydro-Power Pump, you can get three times the rated pump pressure—step up your 1,000 pound pressure to 3,000 pounds. The Hydro-Power Booster can be used with any pump. Valve the discharge through the Booster and up goes your pressure. With the Hydro-Power Booster, ram diameters in newly designed machinery can be reduced to ⅓rd previous areas. For more complete information about the new Hydro-Power Gear Pumps and Boosters, mail the handy coupon.

HYDRO-POWER, INC.
Belmont and Sheridan Aves. · Springfield, Ohio

hydro power *hydraulics*

FOR DEPENDABLE PACKAGED POWER

Recommended For:

- Concrete Block-Making Machinery
- Steel Mill Equipment
- Road Grading Equipment
- Dump Trucks
- Airplanes
- Bulldozers
- Extrusion Machines
- Oil Extraction Machinery
- Snow Plows
- Scarifiers
- Material Handling Equipment
- Baling Machines
- Plastics Molding Machinery
- Die Casting Machinery
- Heavy-Duty Jacks

and many others

Hydro-Power, Inc.
Belmont and Sheridan Aves.
Springfield, Ohio

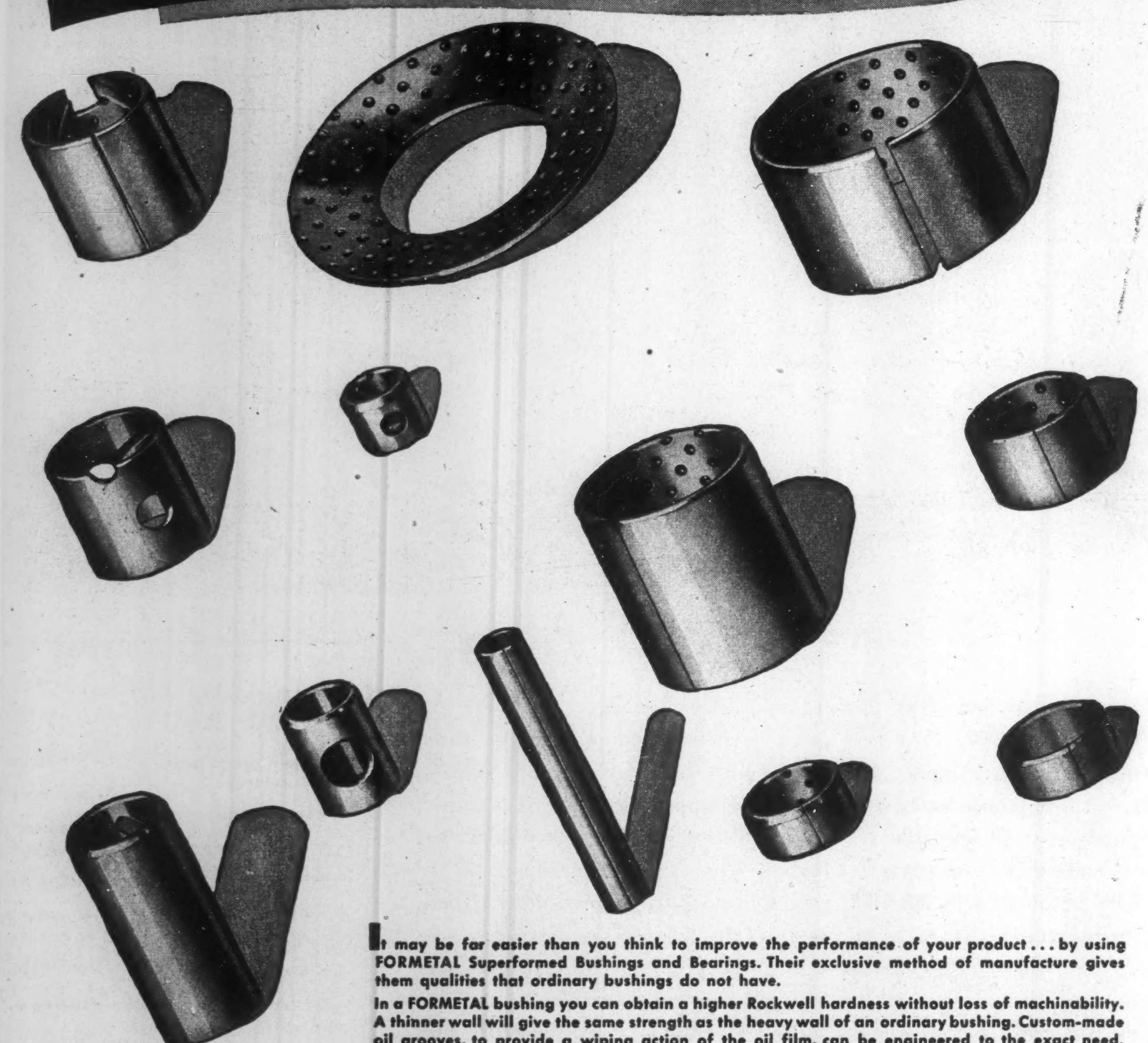
Please send me additional information about your new Cubline Gear Pump and Power Booster.

Name________________ Title________
Company________________________
Street__________________________
City and Zone____________ State________

WHERE THERE'S A WILL . . . THERE'S A WAY

TO IMPROVE PERFORMANCE WITH

FORMETAL *Superformed* BUSHINGS AND BEARINGS



It may be far easier than you think to improve the performance of your product . . . by using FORMETAL Superformed Bushings and Bearings. Their exclusive method of manufacture gives them qualities that ordinary bushings do not have.

In a FORMETAL bushing you can obtain a higher Rockwell hardness without loss of machinability. A thinner wall will give the same strength as the heavy wall of an ordinary bushing. Custom-made oil grooves, to provide a wiping action of the oil film, can be engineered to the exact need.

Made of bronze, steel, or alloy of your specification, FORMETAL bushings or bearings *cost no more than ordinary types.* If you really want to improve performance write for free reference booklet of BUSHINGS, BEARINGS AND SPACER TUBES . . . engineers and buyers will find it tremendously informative.

To get your products really rolling
. . . use FORMETAL!

NATIONAL FORMETAL CO., INC.
ESTABLISHED 1919
Manufacturers of "Superformed" Bushings and Bearings . . . and Spacer Tubes
6604 METTA AVENUE • CLEVELAND 14, OHIO
Offices in DETROIT • CHICAGO • NEW YORK • LOS ANGELES • INDIANAPOLIS

National Formetal Co., Inc. 6604 Metta Ave., Cleveland 14, Ohio
Please send free copy of your new catalog.

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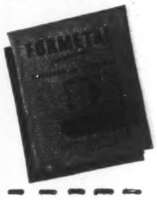
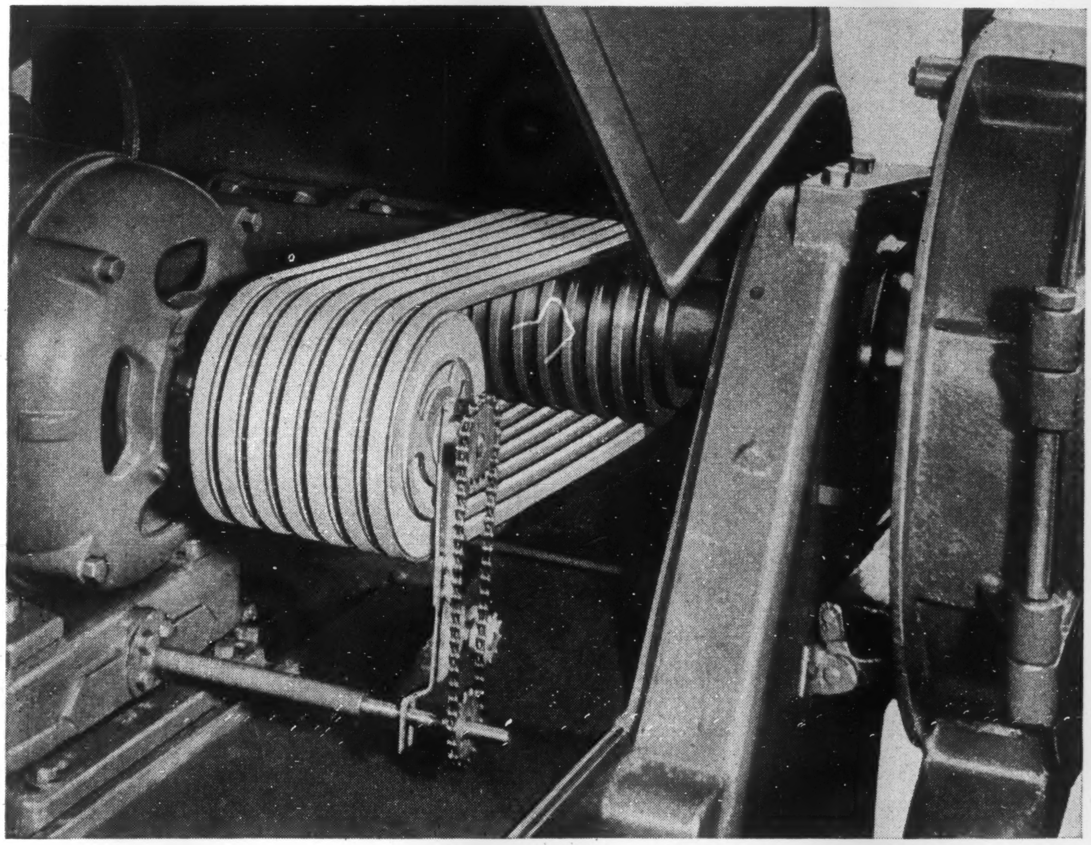
COMPANY..............................
ADDRESS..............................
CITY and STATE..............................





Texrope *VARIABLE* Speed Drive ... the practical way to get Accurate Speed Control

- To regulate a machine tool to suit variations in job, material, or individual workman
- To control the volume of air from heating and ventilating fans
- To vary the speed of a pump, spinning frame, conveyor, rock crusher or grinding wheel
- *Wherever* the ability to change operating speeds at will can add to efficiency, output or economy —

Install Texrope Variable Speed Drives!

These flexible drives use economical constant speed motors. They provide infinite speed variations within their ranges—quickly, easily, accurately.

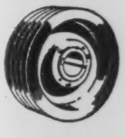
Vari-Pitch sheaves using A, B, C, D or E belts are available for stationary or motion control, with range up to 25% per sheave; *Vari-Pitch* sheaves using Q or R wide belts allow variations up to 100%; *Vari-Pitch* speed changers permit ranges up to 375%. There are types and sizes to suit all needs, from fractional to 300 hp!

Texrope offers the *most complete* line of variable speed drives made... engineered and built by Allis-Chalmers, originator of the multiple V-belt drive. See Sweet's Catalog, or call your nearby A-C office or dealer for Bulletin 20B6051G. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

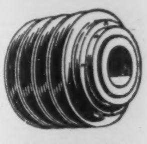
A 2200

TEXROPE ..Greatest Name in V-Belt Drives

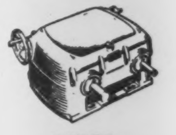
"Super 7" V-BELTS
Five Types — Sizes to suit every power transmission job.



Texsteel, Texdrive, "Magic-Grip"
— sheaves in a full range of sizes, grooves.



"Vari-Pitch" SHEAVES
Exact variations in speed, stationery or motion control.



SPEED CHANGERS
Speed variations up to 375% at the turn of a crank.

ENGINEERING
Finest V-Belt engineering talent in the world—at your call.

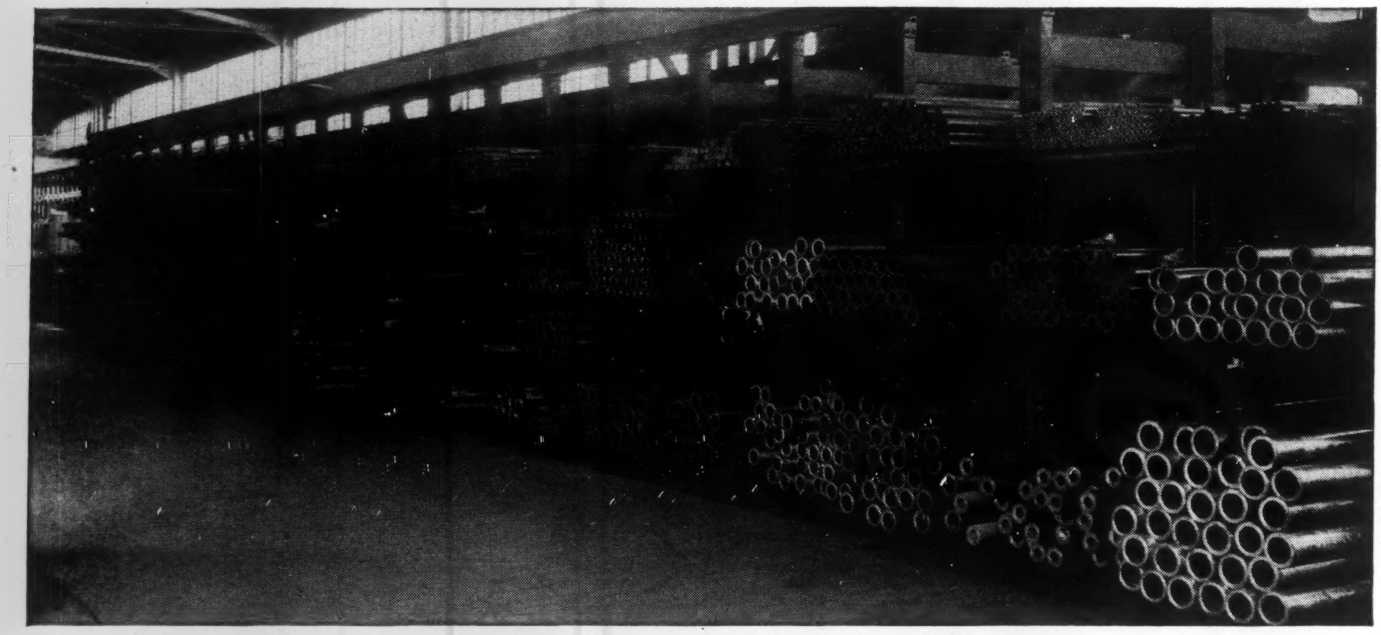
TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

ALLIS-CHALMERS

One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products

1847 AC 1947
A CENTURY OF SERVICE to Industry THAT MADE America Great

NOW! 101 sizes of 52100 tubes for immediate shipment



WE maintain a mill stock of 101 sizes of 52100 Timken seamless steel tubes, ranging from 1″ to 10½″ O.D. That's how we're able to guarantee *immediate delivery* of your emergency orders.

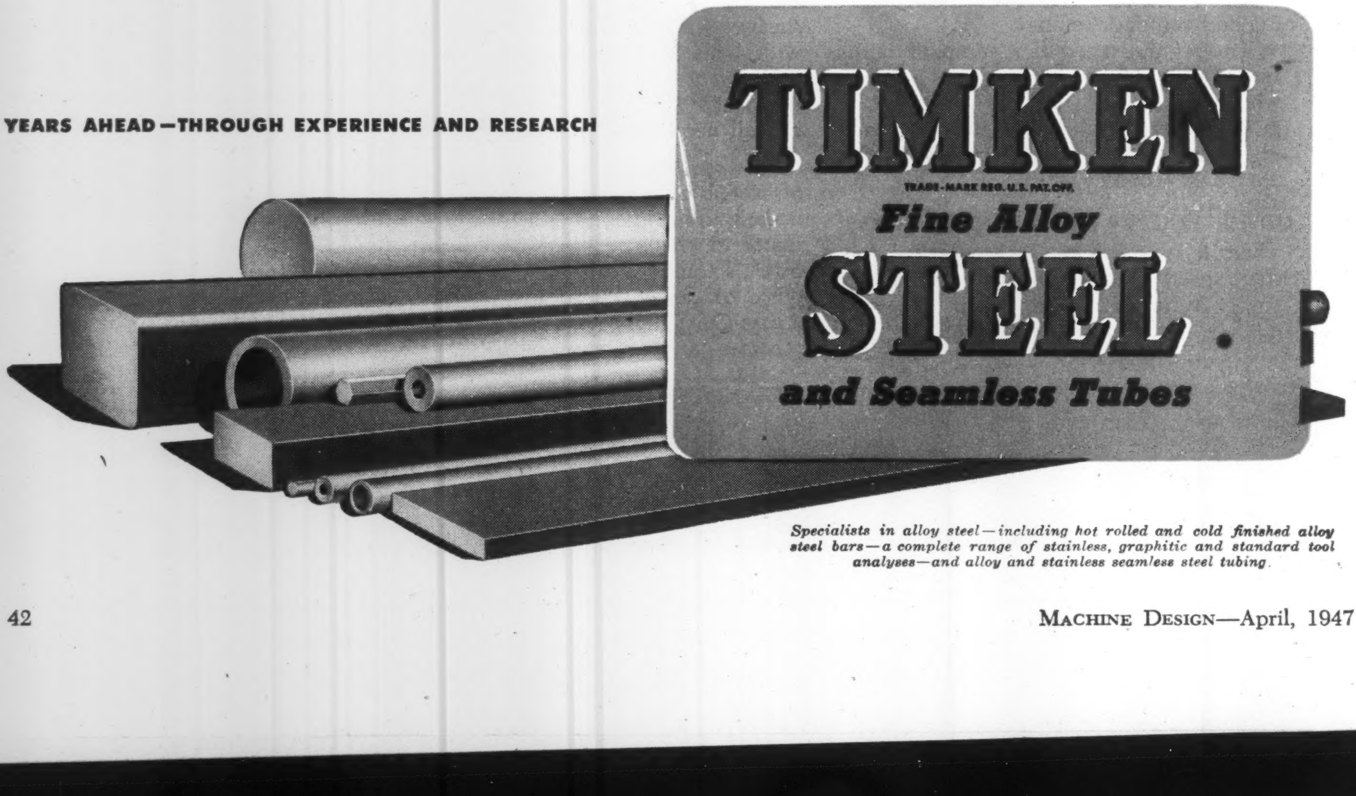
If you would like to be kept up to date on the sizes and finishes of 52100 seamless tubes immediately available from our mill stock, just ask us to add your name to our regular 52100 mill stock mailing list. We'll send you a copy *each month.*

The same excellent machinability, extreme hardenability, high tensile strength and high fatigue strength in each shipment of 52100 seamless steel tubes is assured by the "Timken" label. Every step in the manufacturing of these tubes is controlled entirely within The Timken Company.

We melt the steel, roll the billets, and pierce the tubes, all in our own mill.

For highest quality and quickest delivery of 52100 seamless steel tubes, mail, wire, or telephone your order to Steel and Tube Division, The Timken Roller Bearing Company, Canton 6, Ohio.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

PERMANENT RESILIENCE

Resilient parts made from HYCAR synthetic rubber *stay* resilient. That's partly because of HYCAR's unusual chemical stability—its resistance to oil and gas, acids and most other chemicals. And parts made from HYCAR are extremely resistant to the effects of oxidation, sunlight, and normal aging. A HYCAR sealing ring, for example, will maintain a positive seal through years of service even when constantly exposed to oils and acids inside the pipe, and sunlight and salt air outside.

Other unusual and valuable properties are listed in the box at the right. But most important, these properties may be had in an almost limitless number of combinations, each designed to meet the specific service conditions of the finished part. Parts made from HYCAR have seen service in *every* industry, giving long life, dependability, and economical operation.

That's why we say ask your supplier for parts made from HYCAR. Test them in your own applications, difficult or routine. You'll learn for yourself that it's wise to use HYCAR for long-time, dependable performance. For more information, please write Dept. HN-4 B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

CHECK THESE SUPERIOR FEATURES OF HYCAR

1. *EXTREME OIL RESISTANCE — insuring dimensional stability of parts.*
2. *HIGH TEMPERATURE RESISTANCE—up to 250° F. dry heat; up to 300° F. hot oil.*
3. *ABRASION RESISTANCE—50% greater than natural rubber.*
4. *MINIMUM COLD FLOW—even at elevated temperatures.*
5. *LOW TEMPERATURE FLEXIBILITY—down to —65° F.*
6. *LIGHT WEIGHT—15% to 25% lighter than many other synthetic rubbers.*
7. *AGE RESISTANCE—exceptionally resistant to checking or cracking from oxidation.*
8. *HARDNESS RANGE—compounds can be varied from extremely soft to bone hard.*
9. *NON-ADHERENT TO METAL—compounds will not adhere to metals even after prolonged contact under pressure. (Metal adhesions can be readily obtained when desired.)*

Hycar
Reg U S Pat Off
American Rubber

B. F. Goodrich Chemical Company

A DIVISION OF
THE B. F. GOODRICH COMPANY

HOW CAN YOU DO IT BETTER . . . AND CUT COSTS?

Bendix Home Appliances Found the Answer!

YES, the answer was plastics. These five molded plastic parts in the Bendix Automatic Washer not only *do a better job* than materials previously employed or tested . . . but they save up to *half* in manufacturing costs!

They're molded from BAKELITE general-purpose molding compound—one of industry's great basic materials.

Floats, soap door, trim strip, drain door handle and clothes door handle—all are formed of this versatile phenolic plastic compound.

Impact resistance, heat resistance, chemical resistance, sufficient to meet most general requirements, and *low cost*—these are some of the demands that this BAKELITE plastic satisfies. It has excellent dielectric qualities, too. No wonder it is so widely required for electrical appliances, equipment and accessories . . . both for working parts and for trim. Write Department **14** for Booklet G-4 . . . a concise "round-up" of electrical properties of this and other types of BAKELITE plastics.

TRADE—MARKS

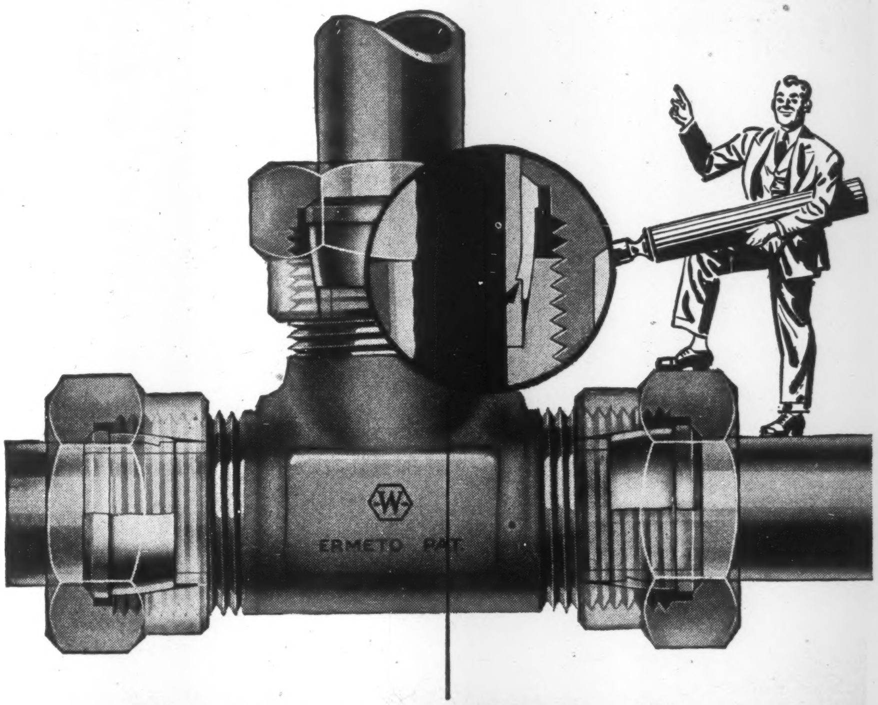
BAKELITE

PLASTICS

BAKELITE CORPORATION, *Unit of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

It'll "stay put"

if you use Ermeto fittings



(Sharp edge of sealing ring cold forms a burst-proof seat in tube.)

THEY'RE made in steel, stainless steel and aluminum bar stock and forgings in O. D. Tube Sizes.

Connections are made without flaring, threading, welding or soldering.

Weatherhead Ermeto fittings will hold beyond the burst strength of the tube itself and will withstand excessive vibration without loosening.

These fittings can be reused again and again. They're more easily installed, give performance superior to any other kind of fitting and are cheaper in the long run than any other type fitting because their unique construction permits the use of thinner wall tubing.

Weatherhead Ermeto Fittings are widely used in the Railroad, Marine, Farm Equipment, Road Machinery, Diesel, Petroleum, Oil Refining, Refrigeration, and Machine Tool Fields.

Write today for the new catalog describing the complete line of Ermeto Fittings.

Look Ahead with

Weatherhead

THE WEATHERHEAD COMPANY, CLEVELAND 8, OHIO

CLEVELAND • NEW YORK • DETROIT • CHICAGO • ST. LOUIS • ATLANTA • DENVER • LOS ANGELES

Weatherhead Products Include:

Power Brake Units • Jet Fuel Control Valves • Liquefied Petroleum Gas Regulators • Relief Valves • Flexible Hose Assemblies • Tube Fittings • Refrigeration Valves • Dehydrators

At your finger tips . . .

Piping Equipment for Every Design

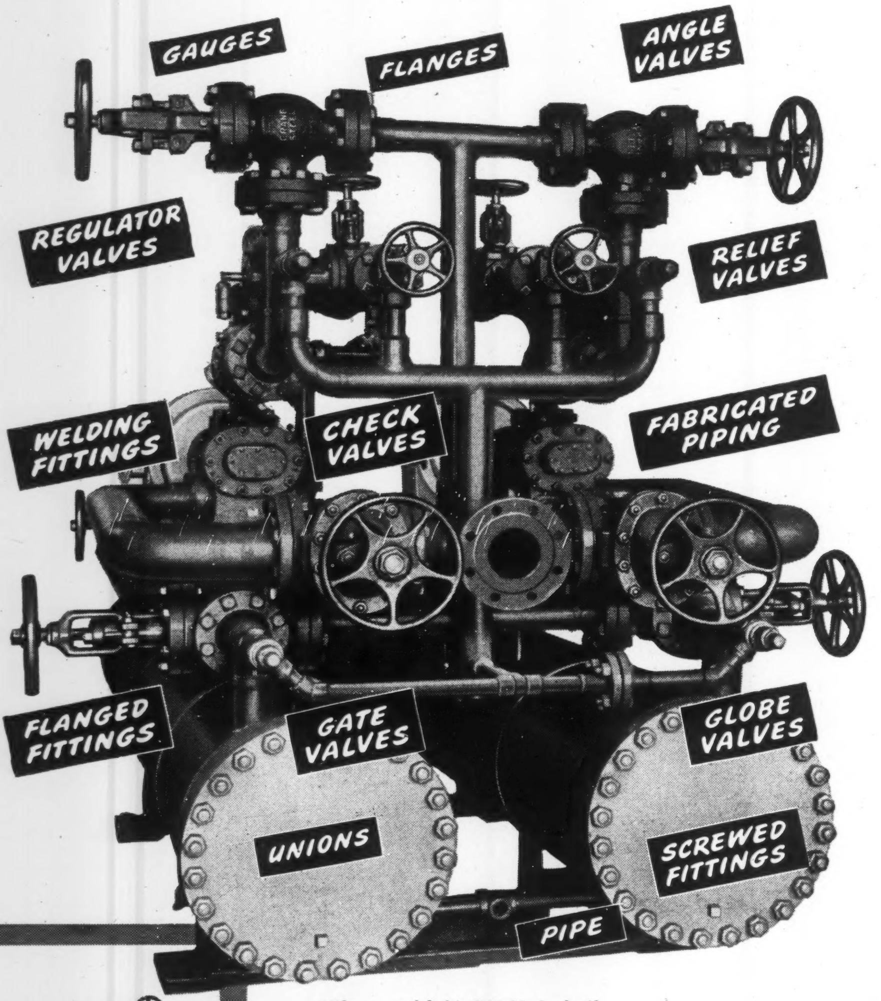
No hunting . . . no time lost . . . when you specify piping equipment from the Crane Catalog. It's organized for quick, easy reference. A truly complete selection is yours . . . the world's largest . . . of valves, fittings, piping accessories, and pipe for every design requirement.

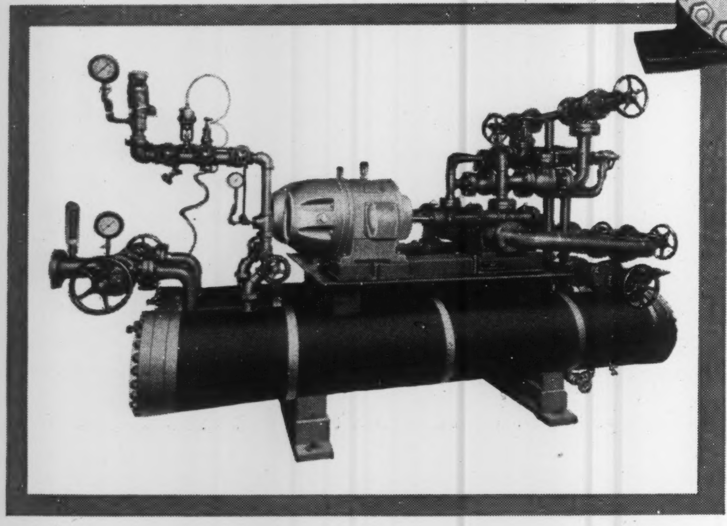
No compromise is necessary whether you're specifying for a simple lubricating line or a complex hydraulic system, for example. Crane offers all types and sizes of piping equipment . . . in brass, iron, and steel. Here's an opportunity to standardize without limitation.

ONE SOURCE OF SUPPLY
ONE RESPONSIBILITY
ONE STANDARD OF QUALITY

Product designer . . . builder . . . and machinery buyer . . . all benefit by the 3-way advantage of standardizing on Crane equipment. As it speeds designing, it simplifies your factory procedures. Your customers get the greater value that Crane equipment has been giving for more than 90 years.

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers in All Industrial Areas.*


GAUGES
FLANGES
ANGLE VALVES
REGULATOR VALVES
RELIEF VALVES
WELDING FITTINGS
CHECK VALVES
FABRICATED PIPING
FLANGED FITTINGS
GATE VALVES
GLOBE VALVES
UNIONS
SCREWED FITTINGS
PIPE



(Above and left) *ENCO fuel-oil pump set by The Engineer Company, designed with Crane piping materials.*

CRANE
STEEL
300

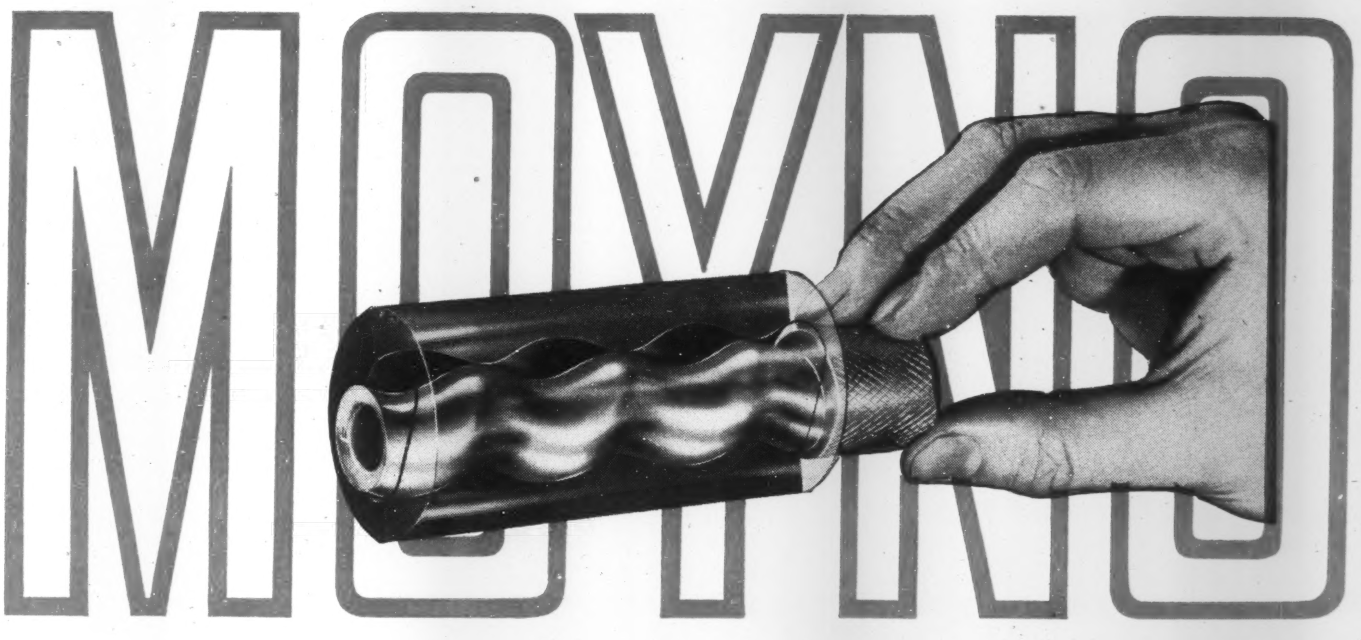
(Right) **IN STEEL VALVES,** *Crane supplies gate, globe, angle and check patterns, in cast and forged materials, in pressure classes for all applications. Also, in a wide selection of corrosion-resistant materials, including bar stock valves. See your Crane Catalog or call your Crane Representative for complete specifications.*

EVERYTHING FROM . . .

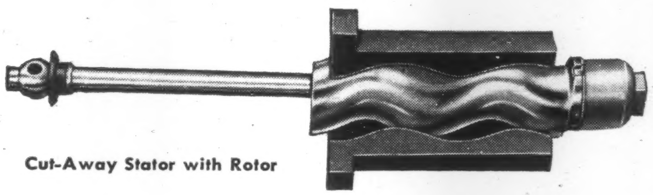
VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM



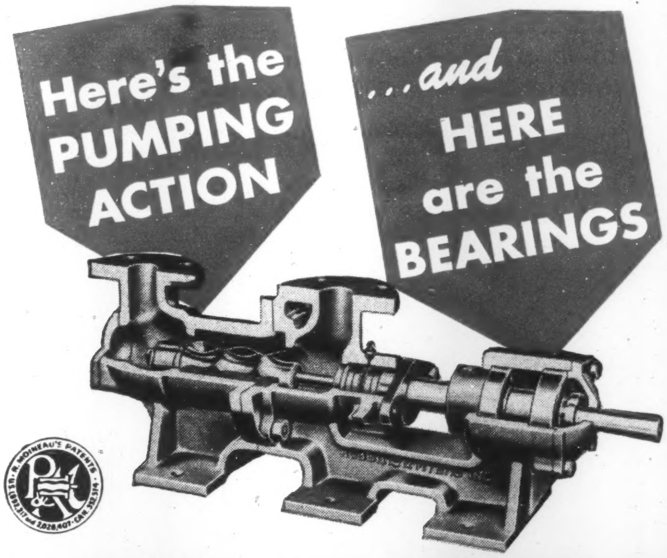
. . . the Pump that Does Everything Well!



Cut-Away Stator with Rotor

NO PISTONS • NO VALVES

This Moyno rotor-stator pumping element does *all* the work, takes *all* the wear. Rotor moves in circular path while revolving in the *reverse* of rolling rotation to sweep particles away from seal lines, or to pass over those imbedded so that following pockets of liquid can flush them free. Elements may be made of materials best suited to the service. Easily replaceable.



Pumping problems vanish when you put in Moynos—the *"screwy pumps"* that handle virtually everything from liquids to non-pourable pastes. They pump without pulsation. Pass particles. Resist abrasives, and chemical attack. Moynos *stand up* where other pumps fail. No body casting has ever worn out.

IF IT WILL PUSH THROUGH A PIPE YOU CAN PUMP IT WITH A MOYNO

There's nothing like the Moyno for "impossible" conditions of abrasion, viscosity, and suspended solids. Continuous, *wedging* pumping action delivers with minimum agitation at pressures up to 1000 p.s.i. Internal velocities are low. Moynos are reversible; self-prime; do *everything* well. They're the pumps without "type" limitations.

NO OTHER PUMP LIKE THIS!

If you use pumps, or ever expect to, you should know about the Moyno. Thousands are in daily service, saving their cost over and over again in *dependable* performance. Made for normal needs, higher pressures, volatiles, and edibles.

FREE BOOK TELLS ALL

Write for It Today

Send for free 16-page booklet, "A Turn for the Better." It explains the simple Moyno principle; gives pressures, dimensions, capacities, uses. Distributors coast to coast.

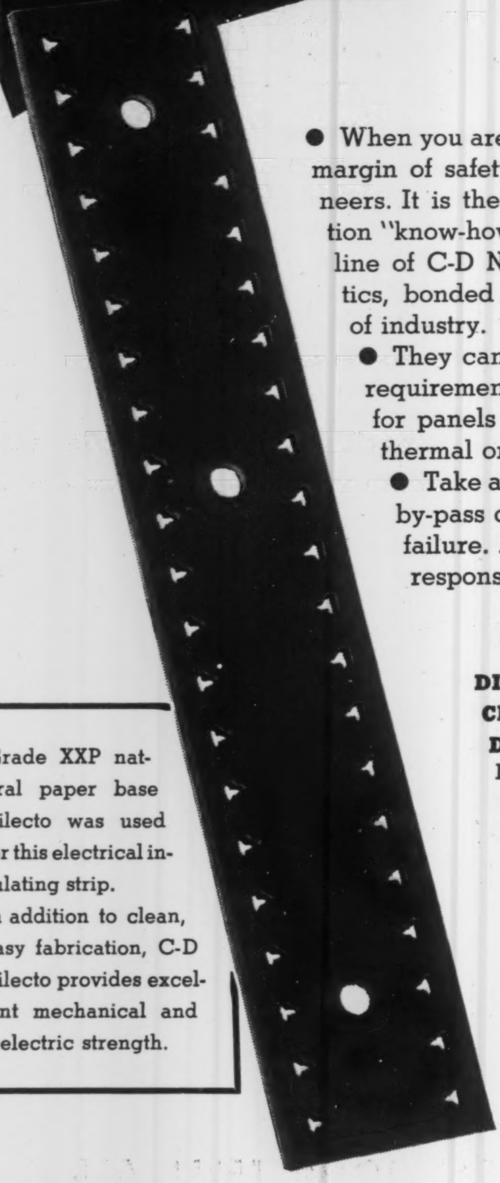
A Turn for the Better
R&M MOYNO PUMP

ROBBINS & MYERS • INC. MOYNO PUMP DIVISION • SPRINGFIELD, OHIO
In Canada: Robbins & Myers Co. of Canada, Ltd., Brantford, Ont.

MOTORS · HOISTS · CRANES · MACHINE DRIVES · FANS · MOYNO PUMPS · FOUNDED 1878

If it's an Insulation Problem . . . this is the name to know.

Continental · Diamond
C–D
Engineered Non-Metallics

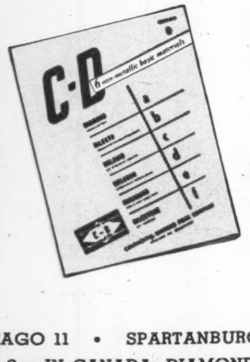


Grade XXP natural paper base Dilecto was used for this electrical insulating strip.
In addition to clean, easy fabrication, C-D Dilecto provides excellent mechanical and dielectric strength.

- When you are looking for better product performance . . . a greater margin of safety in electrical equipment—discuss it with C-D engineers. It is their application experience, coupled with C-D production "know-how", that has led to the development of the complete line of C-D Non-Metallics: molded macerated and laminated plastics, bonded mica and fibre products to meet the specific needs of industry.
- They can advise you which materials best meet high voltage requirements, which should be used for high frequencies, which for panels or instrument cases, as well as those best suited for thermal or moisture conditions.
- Take advantage of this specialized, practical experience and by-pass costly errors in your planning that may cause product failure. A call to our nearest office will find a ready, helpful response from C-D engineers.

C-D NON-METALLIC PRODUCTS

DILECTO—Thermosetting Laminated Plastics.
CELORON—A Molded Phenolic Plastic.
DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.
HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.
DIAMOND Vulcanized FIBRE.
VULCOID—Resin Impregnated Vulcanized Fibre.
MICABOND—Built-up Mica Electrical Insulation



STANDARD & SPECIAL FORMS

Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

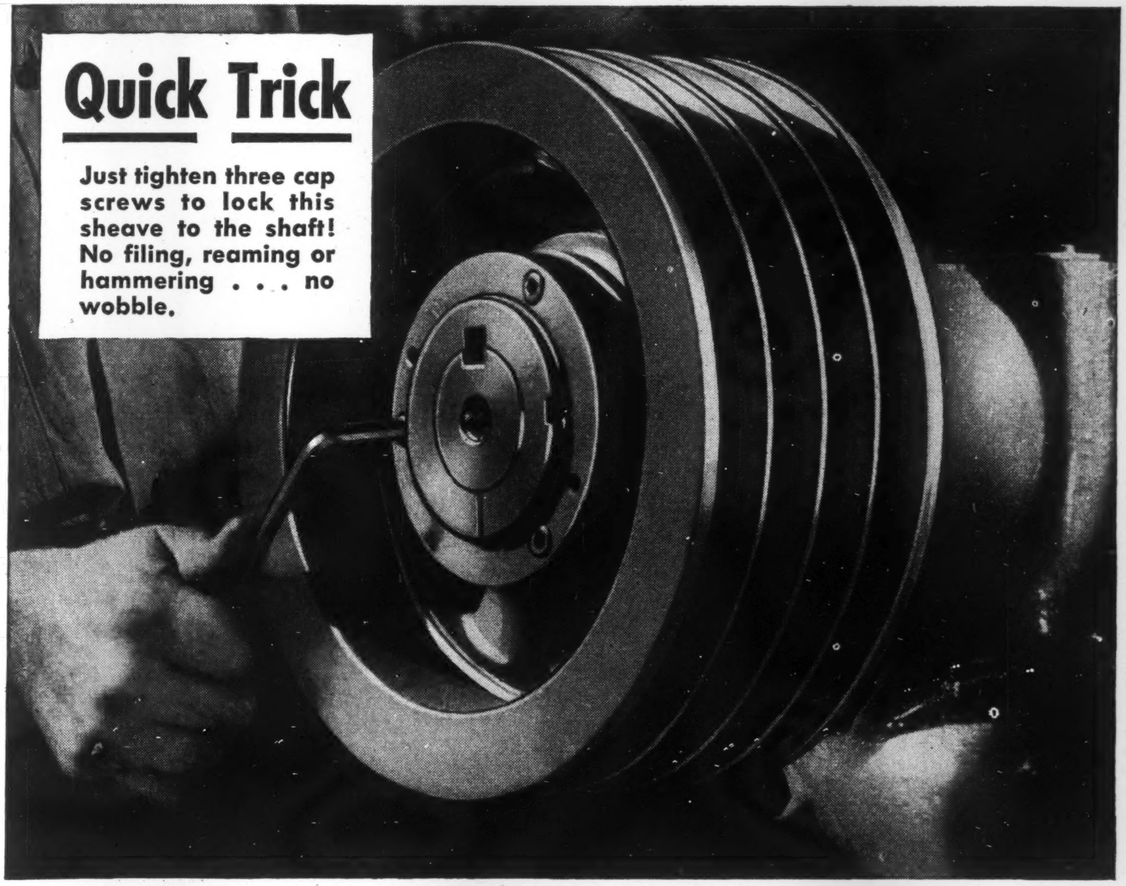
DESCRIPTIVE LITERATURE

Bulletin GF gives Comprehensive Data on all C-D Products. Catalogs are also available.

DE-2-47

BRANCH OFFICES: NEW YORK 17 • CLEVELAND 14 • CHICAGO 11 • SPARTANBURG, S. C. • SALES OFFICES IN PRINCIPAL CITIES
WEST COAST REPRESENTATIVES: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO., OF CANADA, LTD., TORONTO 8

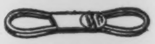
Continental-Diamond FIBRE COMPANY
Established 1895.. Manufacturers of Laminated Plastics since 1911— NEWARK 23 • DELAWARE



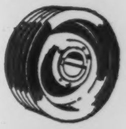
Quick Trick

Just tighten three cap screws to lock this sheave to the shaft! No filing, reaming or hammering . . . no wobble.

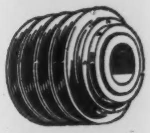
TEXROPE ..Greatest Name in V-Belt Drives



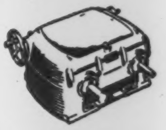
"Super 7" V-BELTS
Five Types — Sizes to suit every power transmission job.



Texsteel, Texdrive, "Magic-Grip"
— sheaves in a full range of sizes, grooves.



"Vari-Pitch" SHEAVES
Exact variations in speed, stationery or motion control.



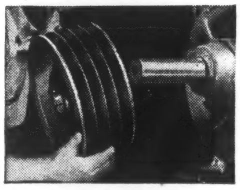
SPEED CHANGERS
Speed variations up to 375% at the turn of a crank.

ENGINEERING
Finest V-Belt engineering talent in the world—at your call.

TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

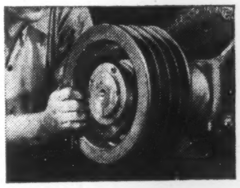
Save time . . . prevent damage to motor and shaft . . . with TEXROPE

"MAGIC-GRIP" SHEAVES



QUICKLY ALIGNED
Because it slides freely on the shaft, it's easy to line up the sheave accurately — for good alignment, smooth operating, longer belt life. It pays to standardize on "Magic-Grip" sheaves.
See Sweet's Catalog

SLIPS ON EASILY
Comes completely assembled. Tapered split bushing provides clearance for even over-size shafts — it's compressed and locked to the shaft with an all-around clamp grip by tightening three cap screws. Can be removed as easily as it goes on.



HERE'S A SHEAVE that goes on *fast*. Less labor cost — less downtime. But that's only part of the saving. There's no forcing or hammering to damage motor bearings — no set screws to mar the shaft. Locks on with a powerful clamp grip that prevents backlash or wobble. And . . . it costs no more than a standard heavy duty sheave of comparable materials and precision workmanship.

Texrope "Magic-Grip" sheaves are made in diameters from 5.4 to 48 inches, two to 12 grooves. They're engineered by Allis-Chalmers, originators of the multiple V-belt drive. For specifications, prices, call your nearest A-C dealer or office. ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN. A 2221

ALLIS-CHALMERS
One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products

1847 1947
A CENTURY OF SERVICE to Industry THAT MADE America Great

DENISON
EQUIPMENT *in* APPLIED
*Hydr*OIL*ics*

Pumps

Motors

Valves

Power Heads

Pumping Units

THE DENISON ENGINEERING CO.
1156 DUBLIN ROAD, COLUMBUS 16, OHIO

Denison 3500 psi *Hy*
Volumetr

Now—high pressure, high volume delivery pumps with efficiencies of 95% or better at continuous duty operating pressures of 3500 psi . . . without the noise and scream usually associated with high-pressure pump units. A new pressure equalization principle eliminates thrust bearings making these pumps the ultimate in simplified and compact con-

struc
provi
plate
assur
beari
able i
of 6,

*Hydr*OIL

1000 SERIES
3500 SERIES

10
shock
accele
drivin
stant
model
provi
applic

Standardized *Hydr*

DENISON
HydrOILic

SMOOTH and sure hydraulic action is now a
your special jobs, using the Denison pumpi
power head. This "packaged" power allows
engineers to build the advantages of hydr
right into your special machines for unus
tion tasks.
The pump unit includes electric motor
pump, oil reservoir and pressure regulating
is easily transported to any part of the plant
head incorporates fully-enclosed hydraulic cy
trol valve, and external control lever; and

DENISON
EQUIPMENT *in* APPLIED
TRADE-MARK *Hydr*OIL*ics*

DENISON *Valves for Hydraulic Circuits to 5000psi*

Denison 5000 psi Relief, Sequence and Unloading Valves are now available for high pressure circuits requiring closely regulative controls. They are offered in three models: with threaded bodies for direct pipe connections—for sub-plate mounting—and for high-pressure systems requiring flange type connections. Write for detailed information.

HydrOILic Pumps Deliver
etric Efficiencies of 95%

struction. A pressure-balanced piston shoe design provides a cushion of oil between shoe and cam plate. A unique two-piece shaft absorbs deflection, assures long trouble-free service with a minimum of bearing wear. Denison HydrOILic pumps are available in three sizes in the 3500 Series, with deliveries of 6, 17 and 32 gpm respectively, at 1200 rpm.

● ● ● ● ● ● ● ● ● ● ● ● ● ● ●

ILic FLUID MOTORS...to 60 HP Output

1000 Series — Smooth, efficient rotary power ends shock-load troubles of frequent stopping, starting, braking, accelerating or reversing. Constant *pressure* contact between driving and driven elements eliminates backlash—with instant reversal of output shaft without injury to motor. Two models, plus speed control attachments and gearhead drives, provide a variety of operating requirements for hundreds of applications.

3500 Series — Powerful, heavy-duty rotary drives with three models up to 60 hp capacities at 1200 rpm. Hydraulically balanced piston shoe action reduces internal friction and wear—eliminates unnecessary parts for more compact construction. Self-lubricating since all moving parts operate in a bath of oil—maintenance time reduced to a minimum.

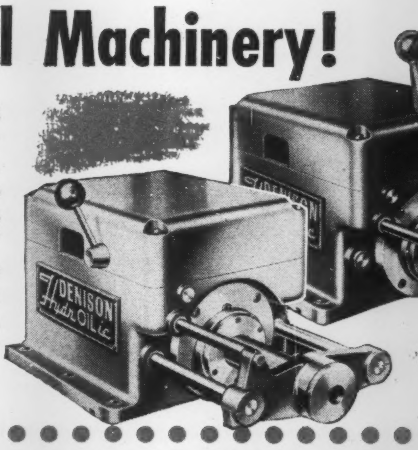
● ● ● ● ● ● ● ● ● ● ● ● ● ● ●

drOILic Power to Fit *Your* Special Machinery!

n is now available for
on pumping unit and
er allows your design
of hydraulic action
for unusual produc-

ic motor, hydraulic
egulating valve—and
the plant. The power
draulic cylinder, con-
ever; and the drive

element (ram) which can be furnished with or without precision type guide rods. Ram pressures can be closely limited anywhere between 300 pounds and 6 tons. Length of ram stroke can be regulated from 1/32-inch to 6 inches. Power heads are available in 2 manual and 4 automatic types, three of which include "vibratory" control for the use of rapid repeat strokes of adjustable pressure, speed and length. Rapid ram traverse with adjustable pressing speeds are other features. Even a combination of all these actions is possible! Write for further information.



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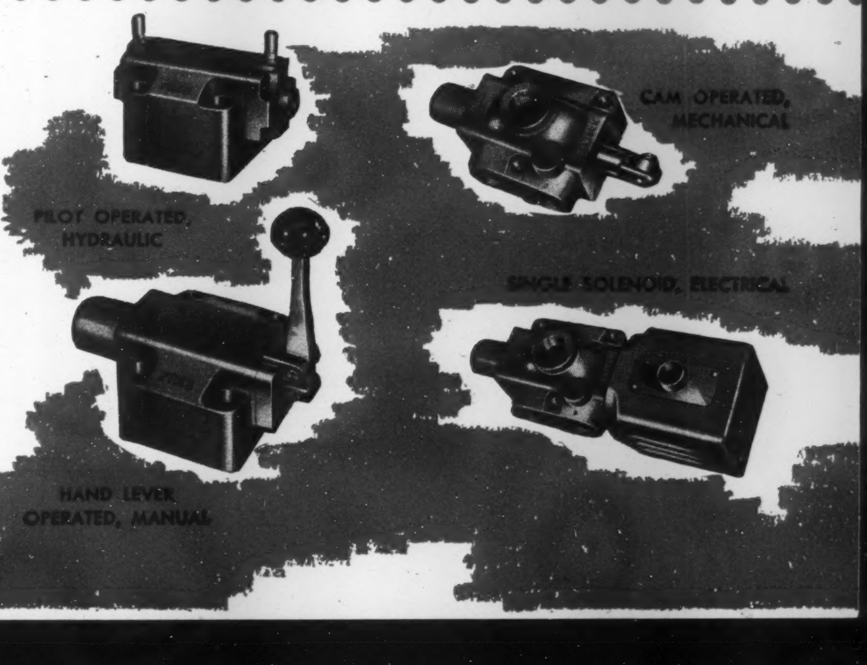
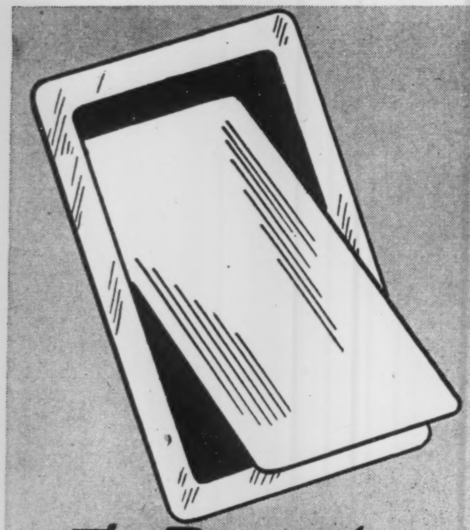
Denison HydrOILic 4-way valves are hydraulically balanced, directional controls for 3500 psi duty, especially designed for high-pressure applications. Heavy, reinforced bodies are featured with sliding spool action for the directional control of oil flow. Maximum volume flow capacities are 20 gpm at a velocity of 20 feet per second. A wide variety of control types can be furnished plus seven standard spool designs—either with threaded body for direct pipe connections or in subplate types for panel-mounting. They are expressly designed to supplement the Denison line of 3500 psi HydrOILic pumps and to provide directional controls for use with the Denison fluid motor line.

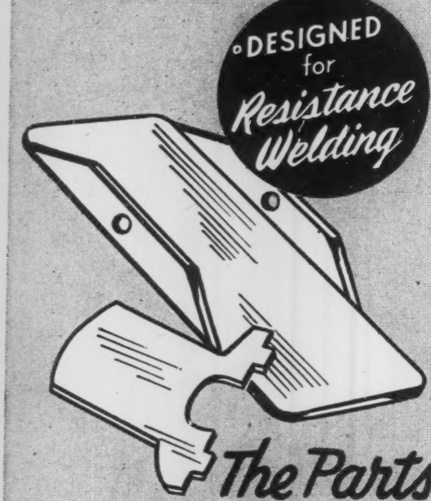

CAM OPERATED, MECHANICAL
PILOT OPERATED, HYDRAULIC
SINGLE SOLENOID, ELECTRICAL
HAND LEVER OPERATED, MANUAL

WELDINGENUITY

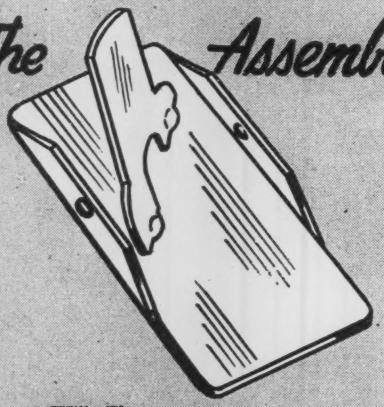
cut the cost 75%



The Product



The Parts

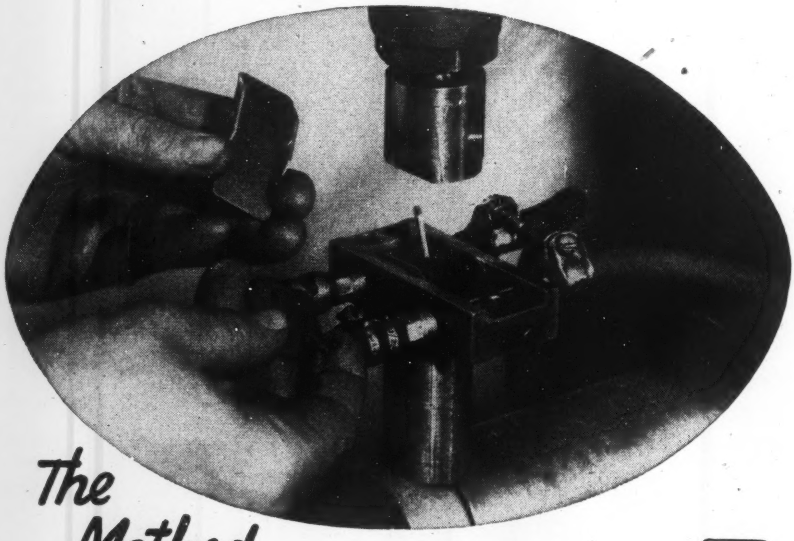
The  *Assembly*

Dedoes of Berkley, Michigan had developed some attractive flush hardware—with no projecting parts—for kitchen cabinets. To make it, however, the trigger cam had to be attached to the finger plate at a compound angle and no surface markings were permissible on the front of the finger plate. Silver brazing seemed the only way out.

Then Progressive's Process Engineering Department looked it over, designed a simple fixture to hold the parts in a projection welder. The two pieces are now rigidly assembled by welding at a clip of 600 an hour at one-quarter of the former cost.

Whether it's a simple machine to turn out a small part or a complex automatic to perform multiple welding operations, Progressive can show you the lowest cost way to do the job.

Are you receiving the Monthly Welding Pictorial? It is full of ideas on lower cost welding methods. Write for it today on your company letterhead.



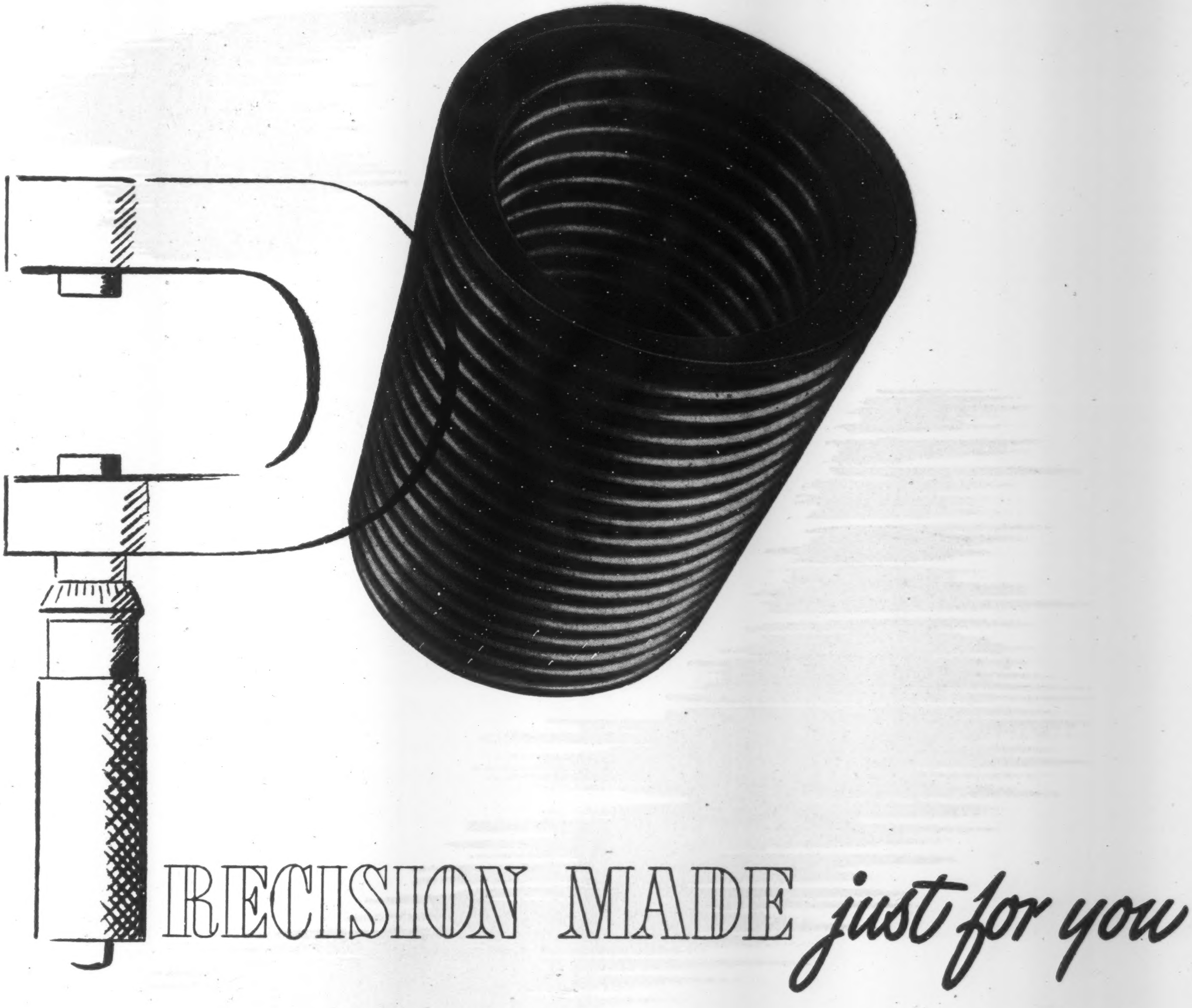
The Method

IT **PAYS** TO WELD

MEMBER RWMA RESISTANCE WELDER MANUFACTURERS' ASSOCIATION

PROGRESSIVE Welder Co. 3050 E. OUTER DRIVE • DETROIT 12

RESISTANCE WELDING EQUIPMENT


PRECISION MADE just for you

Each Bridgeport bellows, bellows device or assembly . . . regardless of its size or the metal from which it is made . . . is precision engineered by skilled specialists.

Each is designed to properly fill all the requirements of your own particular application—as none is sold out of stock.

Successfully used by industry to accurately control temperatures and pressures, absorb expansion, transmit motion, and seal rotating shafts.

Catalog GK-100 gives complete construction details, suggests numerous applications, provides you with ideas which may simplify your product design. Write for your copy today.

Bellows Assemblies . . . Bellows . . . Bellows Devices

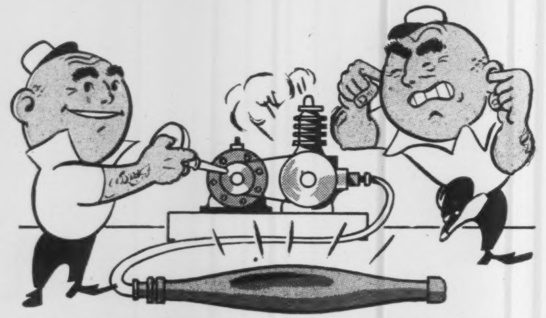
BRIDGEPORT THERMOSTAT

COMPANY, Incorporated • Bridgeport 1, Conn.

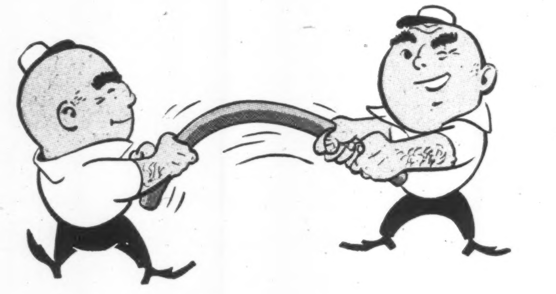
For men who won't take wooden nickels

The welcome mat at Bundy is always out for men who won't take wooden nickels.

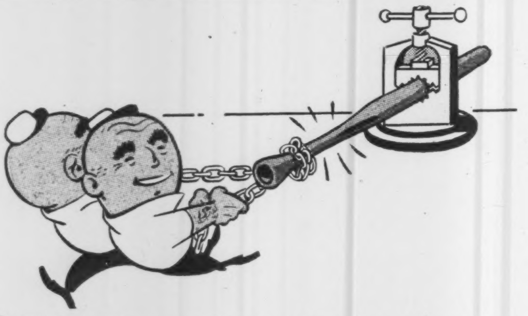
Manufacturers have a right to be skeptical until they've seen the proof that Bundyweld Steel Tubing is *superior . . . different.* And to provide that proof, here's the story of superiority our design engineers tell:



1 **IN PRESSURE** applications, for example, Bundyweld ¼″ x .028″ Annealed Steel Tubing has an ultimate bursting strength of 12,500 pounds per square inch.



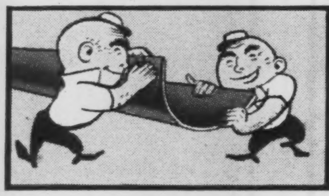
2 **WHERE VIBRATION** occurs, Bundyweld counters with a record of unusually high fatigue strength to insure against failures.



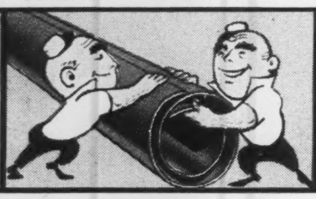
3 **BUNDYWELD'S** ultimate tensile strength (annealed) is 45,000 to 52,000 P.S.I. . . . yield strength, 30,000 to 36,000 P.S.I. . . . percent elongation in 2″, 30% to 40%.

4 **WHEN IT** comes to temper, Bundyweld Steel Tubing can be furnished either with a soft anneal or hard drawn as required.

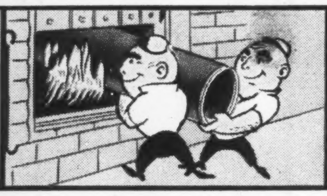
HOW BUNDYWELD IS MADE



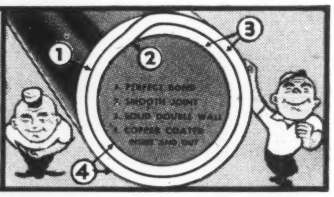
Bundyweld Tubing is made by a process entirely different from that used in making other tubing. A single strip of copper-coated S.A.E. 1010 steel is continuously rolled twice laterally . . .



. . . into tubular form. Walls of uniform thickness and concentricity are assured by the use of close tolerance cold rolled strip. This double rolled strip passes through a furnace where the . . .



. . . copper coating fuses and alloys with the double steel walls. After brazing and cooling, it becomes a solid double wall steel tube, copper brazed throughout 360° of wall contact . . .



. . . copper coated inside and out, free from scale, closely held to dimensions. Hard or annealed in standard sizes up to ⅝″ O.D. Special sizes cold drawn to specifications.

No wonder, then, that Bundyweld Steel Tubing is specified by hundreds of discerning manufacturers for products ranging from motor vehicles to refrigerators and from gas ranges to Diesel engines. If your requirement is for outstanding mechanical properties, let us tell you more about Bundyweld. Also available in nickel and Monel. Write: *Bundy Tubing Company, Detroit 14, Michigan.*

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES:

Pacific Metals Co., Ltd.
3100 19th St.
San Francisco 10, Calif.

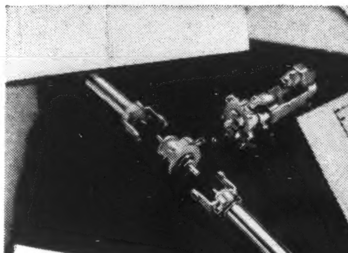
Standard Tube Sales Corp.
1 Admiral Ave.
Maspeth, N.Y.C., N.Y.

Lapham-Hickey Co.
3333 W. 47th Place
Chicago 32, Illinois

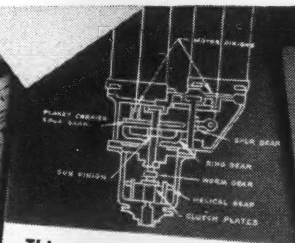
Rutan & Co.
404 Architects Bldg.
Phila. 3, Pa.

Eagle Metals Co.
3628 E. Marginal Way
Seattle 4, Wash.

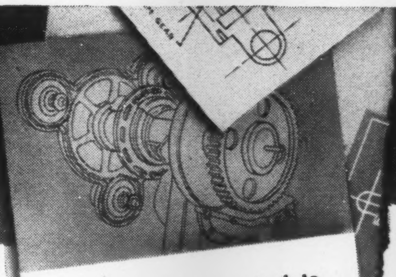
Alloy Metal Sales Ltd.
861 Bay St.
Toronto 5, Canada



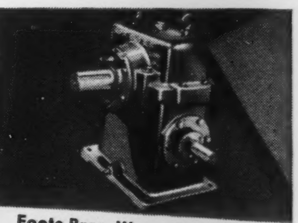
This compact unit produced in Foote Bros.' Precision Gear Division operates the speed brake on the McDonnell Phantom. The high speed of these Navy fighters demands instant control—possible with Foote Bros. Actuators.



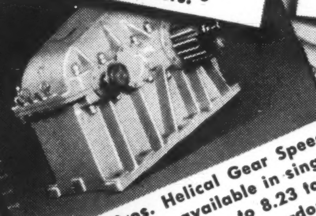
This rotary flap actuator is part of the wing flap system of a large airplane. It is one of many actuators and power units produced in the Precision Gear Division. Manufacturers in other fields are calling on Foote Bros. for aid in applying remote control to machinery they produce.



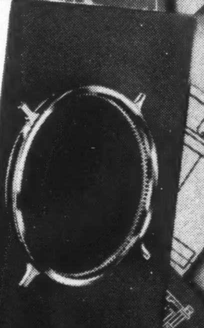
Many manufacturers look to Foote Bros. for the production of special machinery such as this driving mechanism for automatic reels produced in the Industrial Gear Division. This mechanism is part of the paper feed drive on large rotary newspaper presses.



Foote Bros. Worm Gear Speed Reducers are compact, highly efficient units available in right angle, parallel or vertical shaft drives. Single worm types in ratios up to approx. 90 to 1, capacities to 125 h.p. Helical-worm and double-worm types with ratios from 50 up to 8,000 to 1, capacities up to 35 h.p.



Foote Bros. Helical Gear Speed Reducers are available in single reduction ratios up to 8.23 to 1, capacities up to 300 h.p.—double reduction ratios from 9.95 to 68.2 to 1, cap. to 200 h.p.—triple reduction ratios from 80 to approx. 300 to 1, cap. to 100 h.p.



This internal ring gear is one of the many "A-Q" (aircraft quality) Gears produced by Foote Bros. These precision gears, providing the absolute minimum in weight, carry excessive loads at extremely high speeds. Their design and accuracy assure unusually efficient performance.

Pages From An Engineer's Notebook

Shown here are a few of the many problems in power transmission that have been solved by Foote Bros.' Engineers. Look to Foote Bros. for the following equipment:

PRECISION GEARS that permit operation at extremely high speeds, assure maximum efficiency, compactness and low noise level, Foote Bros. "A-Q" Gears can be engineered to meet your toughest requirements.

POWER UNITS to fit any space envelope and to provide absolute control within an exact time cycle at any distance from the operator, Foote Bros.' experience can help you.

SPEED REDUCERS in a wide range of sizes and ratios to meet practically every industrial need, are also a part of Foote Bros.' line.

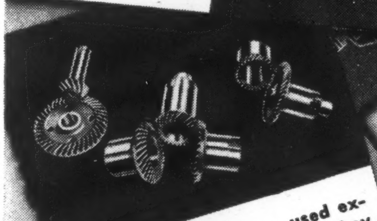
COMMERCIAL GEARS from 3 inches diameter up to 25 feet produced in any quantity—on a monthly delivery basis if desired.

In fact, no matter what your requirements in power control or transmission, the extensive facilities of Foote Bros.' two large plants, the skilled engineers, the three quarters of a century of experience back of this company assure your getting a satisfactory answer.

FOOTE BROS. GEAR AND MACHINE CORPORATION • Dept. 0, 4545 S. Western Blvd., Chicago 9, Ill.

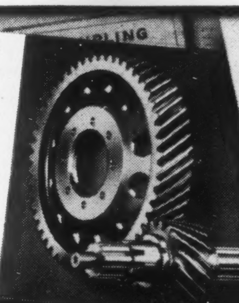
FOOTE BROS.

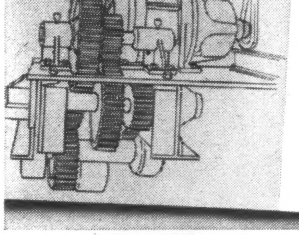
Better Power Transmission Through Better Gears



Spiral bevel gears are used extensively in aircraft because they transmit approximately 30% more power than straight bevel gears of corresponding size and weight. Foote Bros. produce spiral bevel gears in a wide range of sizes.

Spur, helical, worm or bevel gears to meet any production schedule . . . cast iron, steel, bronze or non-metallic in the following sizes:
Spur Gears, 16 D.P. to 4½ in. C.P. From 1 in. to 25 ft. Diam. •
Helical Gears, 16 D.P. to 1½ in. D.P. From 1 in. to 98 in. Diam.
Worm Gears, 16 D.P. to 1 D.P. From 2½ in. to 144 in. Diam.
Bevel Gears, 16 D.P. to ½ D.P. From 1 in. to 100 in. Diam.

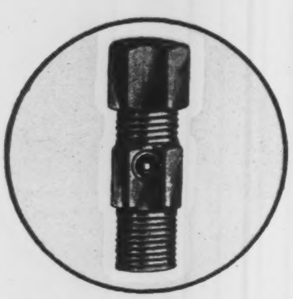




This complete gearing application was produced in the Industrial Gear Division of Foote Bros. for a manufacturer of locomotive turntables. It demonstrates the ability of this division to produce special machinery of all types for developing or transmitting power. Foote Bros. will help you with any equipment you are designing.

FLEXIBLE COUPLING

The complete facilities in Foote-Bros. Industrial Gear Division include equipment for producing giant gears up to 25 feet in diameter. The spur gear shown here, for a cement mill, weighs 40,000 lbs. and has an 18-inch face, 4 inches C.P. Whatever you need in large gears call on Foote Bros.



PULSOLATOR

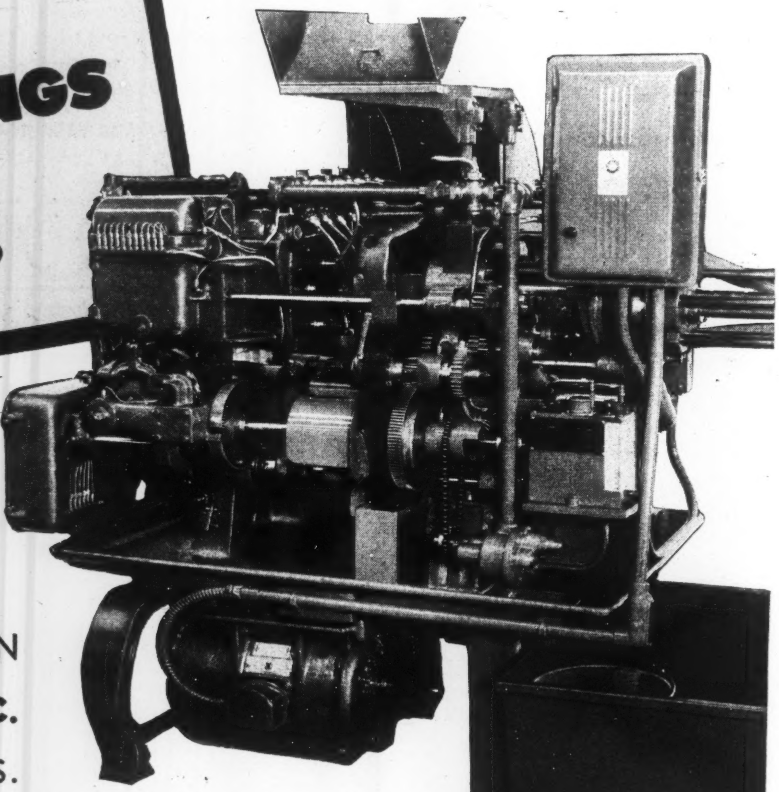
Lubricating Lifelines

For more than fifteen years, hundreds of Davenport Screw Machines, each with more than fifty bearings, have depended upon this control feed lubrication system to maintain automatically the required oil film on each bearing.

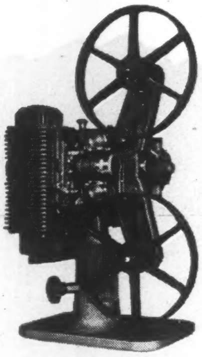
Write today for Pulsolator's proven performance record on such screw machines. See how it does a big job with little effort, reduces operating and maintenance costs, and adds greatly to the earning power of the machine by providing dependable automatic lubrication.

Let a Rivett engineer plan the exact system to be built into your new machines or applied to existing ones. Engineers and machine designers should have up-to-date and complete information on such systems. Send for your copy of Pulsolator's Engineering Manual.

to
51,242 BEARINGS
on DAVENPORT
SCREW MACHINES

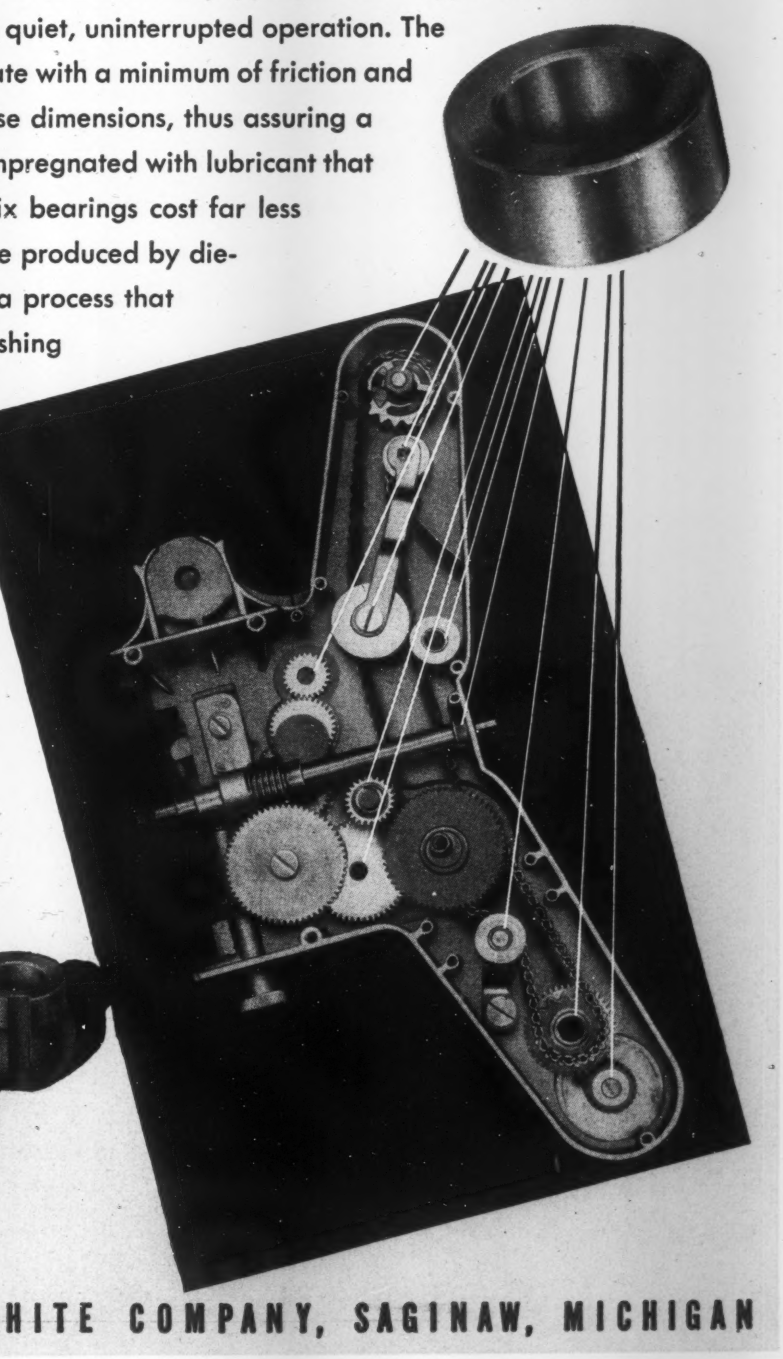


LUBRICATION DIVISION
RIVETT LATHE & GRINDER INC.
BRIGHTON • BOSTON • MASS.



Gramix bearings reduce noise and wear to an absolute minimum in Revere 8 mm. film projector

If you're looking for a way to make your mechanical products operate more quietly and dependably — and at the same time decrease your production costs — you may find the answer in Gramix metal powder parts. The Revere Camera Company of Chicago did. This firm is equipping its latest type motion picture projector with Gramix bearings to insure quiet, uninterrupted operation. The eleven tough little Gramix bearings operate with a minimum of friction and noise because 1) they are made to precise dimensions, thus assuring a close fit, and 2) their porous structure is impregnated with lubricant that will last the life of the projector. Gramix bearings cost far less than machined bearings because they are produced by die-pressing powdered metal to exact size—a process that eliminates expensive machining and finishing operations. Gramix bearings have perfect bearing surfaces. They can be manufactured to almost any size, shape or dimension. Send us sketches or prints of your products. Our engineers will show you where Gramix bearings, washers, seals, gears, or other parts will improve mechanical performance and save you money.



Gramix

THE UNITED STATES GRAPHITE COMPANY, SAGINAW, MICHIGAN

Specifications alone

DO NOT MAKE A WORM GEAR

Efficient operation and satisfactory trouble-free performance over long periods depend not only upon close adherance to engineering specifications but also upon the selection of materials, highly developed production techniques and high standards of quality control.

The excellence of De Laval worm gears is the result of a combination of all these factors, insuring a quality product that has been proven by the highly satisfactory performance of De Laval worm gears for nearly a quarter of a century.

DE LAVAL

WORM GEAR DIVISION

ATLANTA • BOSTON • CHARLOTTE • CHICAGO • CLEVELAND • DENVER • DETROIT
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PITTSBURGH • ROCHESTER • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO
SEATTLE • TORONTO • TULSA • VANCOUVER • WASHINGTON, D. C. • WINNIPEG

DE LAVAL STEAM TURBINE COMPANY • TRENTON 2, NEW JERSEY

WG-3

TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS • CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS AND COMPRESSORS • IMO OIL PUMPS

Steel-Weld FABRICATION

Fabrication of welded steel for any purpose—regardless of size, shape, weight or construction—will be turned out by the Mahon organization in record time . . . it will be the work of master craftsmen backed up by every modern facility to minimize production costs. And, in addition, experienced Mahon design engineers are available for consultation and on the job to see that every advantage of Steel-Weld Fabrication is applied to your requirements.

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Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

MAHON

Scovill

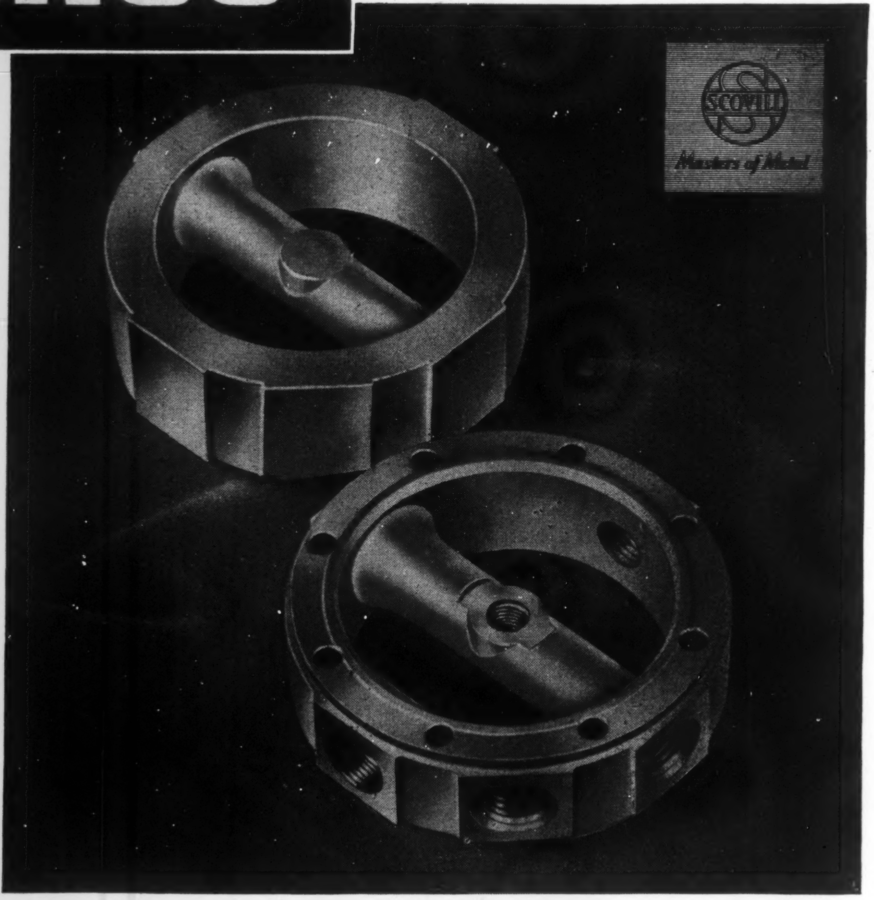
NON-FERROUS

FORGINGS

When SCOVILL becomes your METAL PARTner

Maybe You, Too, Can Use the Same Design for 15 Years

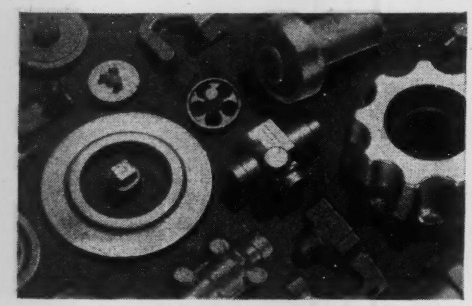
Here you see a brass forging before and after machining. Scovill engineered it 15 years ago for a maker of oxyacetylene welding equipment to replace sand castings . . . and has forged it ever since. Machined by the customer, it serves as satisfactorily today as in 1932 . . . a rarity in these days of frequent design changes. The superiority of forging over sand casting for such an intricately machined part is apparent: fewer rejects after costly tooling.



Your brass, aluminum and other non-ferrous metal parts may be costing you more than they should or may be ready for a quality-lifting improvement in design. In either case, it costs you nothing to investigate Scovill's long experience in forging and the superior facilities at your service.

GET THE FACTS

To learn whether you, too, can benefit from making Scovill your METAL PARTner, fill in the coupon below and mail it today. Scovill Manufacturing Company, Waterbury 91, Conn. *Export Department:* 405 Lexington Avenue, New York 17, N. Y.



Please send me information about your metal-working facilities. I am interested in non-ferrous forgings for the applications checked:

- ☐ Aircraft
- ☐ Automobiles
- ☐ Band Instruments
- ☐ Blow Torches
- ☐ Cameras
- ☐ Communication Equipment
- ☐ Cylinder Valves
- ☐ Fire Extinguishers
- ☐ Household Appliances
- ☐ Industrial Instruments
- ☐ Plumbing Goods
- ☐ Pumps
- ☐ Valves
- ☐ Welding Equipment

Other applications..

....

SCOVILL MANUFACTURING COMPANY
Forgings Division
19 Mill Street
Waterbury 91, Connecticut

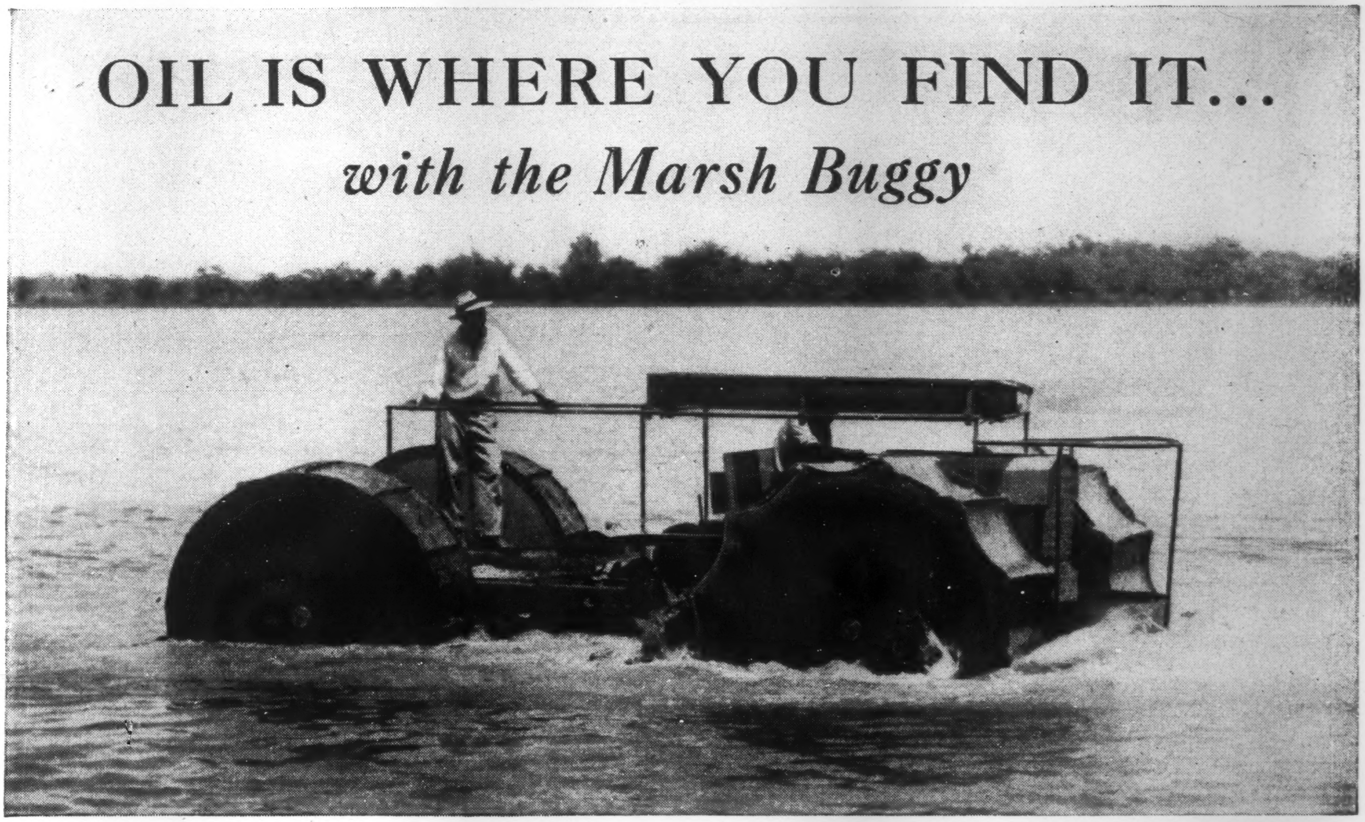
Name ....

Company ....

Address ....

OIL IS WHERE YOU FIND IT...

with the Marsh Buggy



Marsh Buggies, such as the above, are being used today by 16 major companies in all parts of the world. Manufactured by Ironcraft, Houston, Texas.

... and that may be in many hard-to-get-at places.

To locate oil deposits hidden under treacherous swamplands, geologists called for a vehicle which would walk, wade, and swim.

The Marsh Buggy (see above) proved the solution to their problems. It carries men and equipment over dry land, across sticky marshes and deep lagoons ... impassable places to cars, trucks or boats.

Great drum-like, airtight wheels give the buggy its buoyancy in the water ... its traction in slippery ooze. They also serve as steering and propulsion units.

Selecting the proper metal to cover these wheels was of prime importance. This metal had to have plenty of strength and stamina. It needed hardness to withstand the grinding action of sharp, coarse sand, mud, and rough swamp grass.

It had to resist the corrosive attacks of salt and stagnant swamp waters.

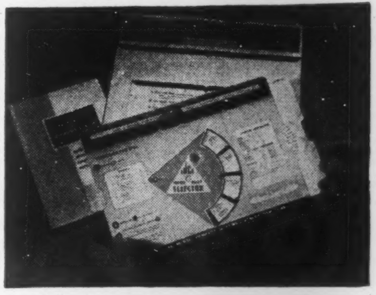
What metal would you have chosen to meet and beat that tough assignment?

The Marsh Buggy's designers, after much experimenting, discovered the answer ... tough, corrosion-resistant Monel*.

* * *

Are you faced with conditions calling for special characteristics in a metal? If so, let Monel, or one of the other INCO Nickel Alloys, help you. As a group they are strong, rustless, corrosion-resistant, and hard. In addition, each offers individual properties to suit specific needs.

The handy INCO Metal Selector Kit gives you a fund of useful facts about Monel and the other INCO Nickel Alloys. Included also is a 20-page booklet of comparative data on 104 ferrous and non-ferrous metals and alloys. It's yours for the asking. Write today.



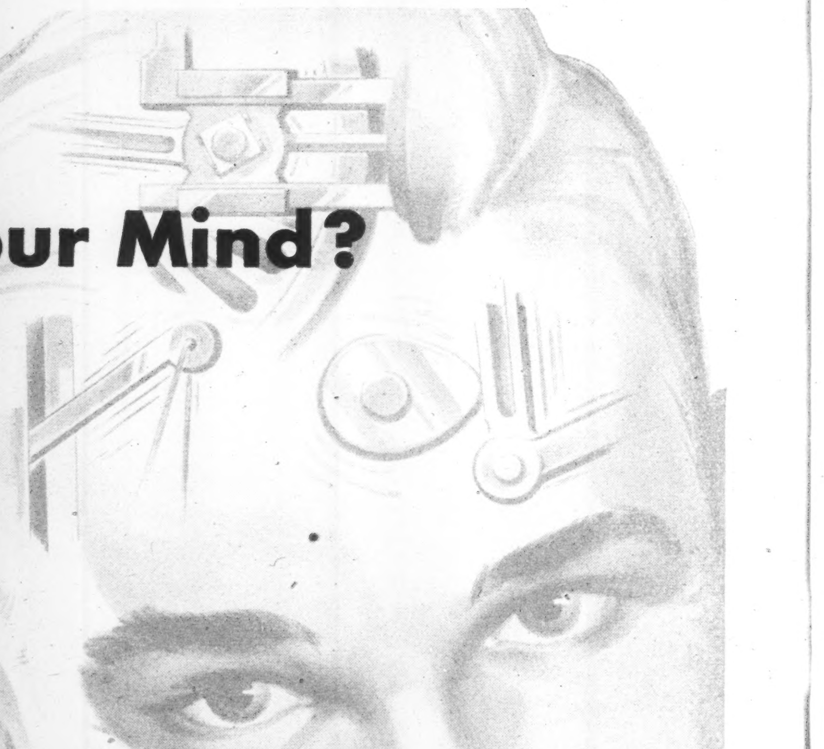
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N.Y.

NICKEL INCO ALLOYS
TRADE MARK

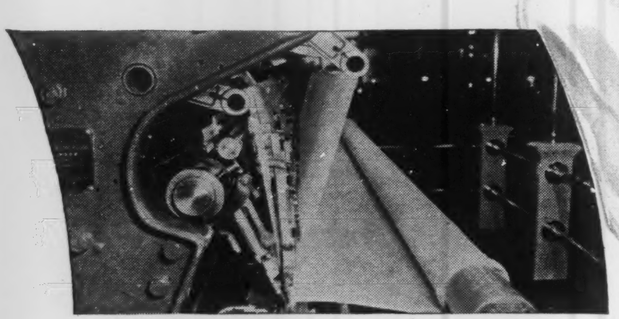
MONEL* • "K"* MONEL • "S"* MONEL • "R"* MONEL • "KR"* MONEL • INCONEL* • NICKEL • "L"* NICKEL • "Z"* NICKEL

*Reg. U. S. Pat. Off.

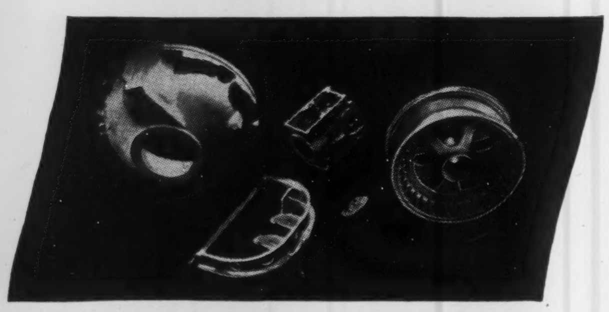
Motion on your Mind?



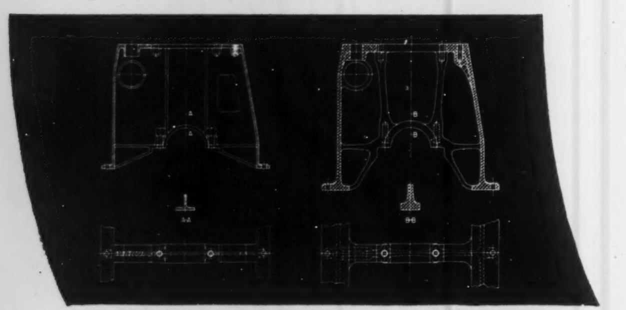
DESIGN FOR A BONUS IN LIGHTNESS!



FREE MOTION with these textile knitting machine needle bars of *American* Magnesium, which reciprocate at high speeds with minimum vibration, show long service life.



CAST by the permanent-mold process, *American* Magnesium provides close tolerances, less finish allowance, high-speed machining to a fine finish.



DESIGNING with *American* Magnesium offers no radical problems. Thickening of cross sections, careful blending and filleting section junctions, are examples of the simple changes necessary.

More and more, modern machinery calls for parts that reciprocate, travel, rotate, swing . . . at higher and higher speeds. 35% lighter than aluminum, 75% lighter than steel, *American* Magnesium gives you motion unhampered by heavy weight . . . and production savings, also. Complex parts may be cast, forged, drawn or extruded in this strong, feather-light metal. It machines easily, at high speeds . . . is easily welded.

How to design? Draw freely upon light metal know-how—the 59 years' experience of Aluminum Company of America. Not only for design and production help, but for our knowledge of the *economics* of light metals that will help you use magnesium where it should be used.

Take your first step toward a bonus in lightness today. Write for "Designing With Magnesium", sent on request, or call your nearest Alcoa sales office. ALUMINUM COMPANY OF AMERICA, sales agent for American Magnesium Products, 1703 Gulf Building, Pittsburgh 19, Pennsylvania.

MAGNESIUM MAZLO PRODUCTS
Reg. U S Pat. Off.

AMERICAN MAGNESIUM CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA

ELECTROL'S NEW COMMERCIAL RELIEF VALVE

ELECTROL INC.
KINGSTON, N.Y.
ASSEM. NO
SERIAL NO

LENGTH OVERALL, 5"

Specifications

MODEL #523-8

PRESSURE RANGE: 100 to 2100 PSI. The range is very small from cracking to full open to re-seating.

SIZE: Length overall, 5". Width, mounting side, 2". Width, port side, 1⅜".

PORTS: Two 3-8/18" NPT. One pressure, one return, in same plane.

MOUNTING: Two holes 1⅜" apart for 10/32" NF-3 bolts.

MATERIAL: Steel and aluminum alloy.

WEIGHT: One and one-half (1½) pounds.

FLOW: Up to six (6) gallons per minute.

CONTROL: Fast and accurate.

ANOTHER MODEL WITH ¾" NPT PORTS ALSO HAS A PRESSURE RANGE OF 100 TO 2100 PSI.

ELECTROL

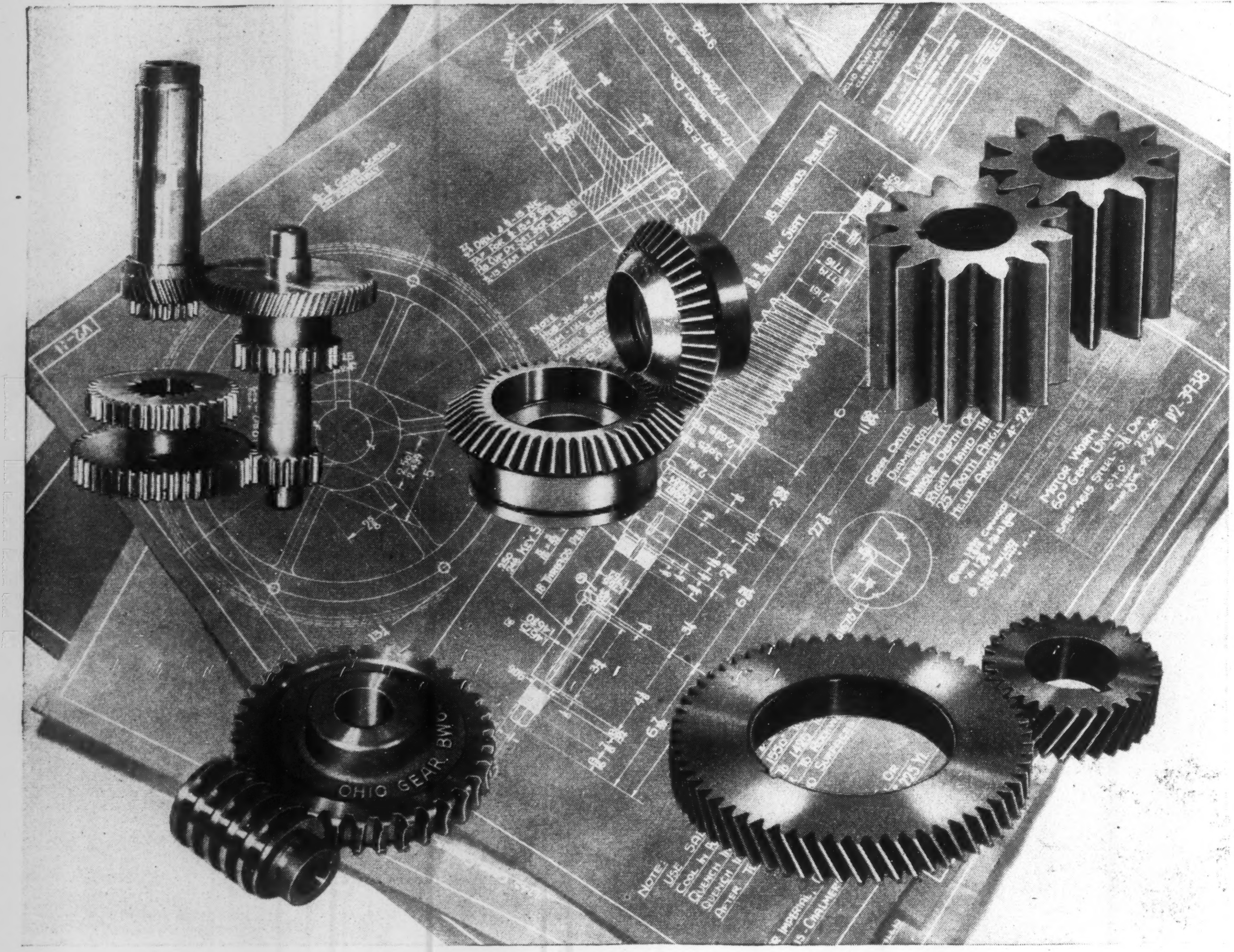
INCORPORATED

FOR BETTER HYDRAULIC DEVICES

KINGSTON, NEW YORK

CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES • CHECK VALVES • RELIEF VALVES
HAND PUMPS • POWERPAKS • OLEO STRUTS • SOLENOID VALVES • ON-OFF VALVES
SERVO CYLINDERS • TRANSFER VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

OHIO SPECIAL GEARS



Whether the gears you specify are simple or complex, you'll find that Ohio Special Gears fit your specifications in every detail. For more than a quarter century Ohio Gear engineers and craftsmen have had an unexcelled reputation for turning specifications into power transmission components of highest industrial quality.

Ohio Special Gears include Spur, Bevel, Miter, Helical and Spiral Gears, Sprockets, Spline Shafts and other allied products.

We have the most modern equipment available, including the latest types of turning, gear cutting, shaving and lapping machines. Complete departments also include controlled heat treating, external, internal and thread grinding, splining and broaching.

Recent increases in production equipment permit the acceptance of limited quantity runs on which we are able to assure exceptionally good deliveries.

We will be glad to assist in your gear production problems and to quote on your specifications.

THE OHIO GEAR COMPANY
1338 EAST 179th STREET • CLEVELAND 10, OHIO

REPRESENTATIVES

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1315½ Hertel Ave., Room 9

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George P. Coulter
4 W. Larned St.

GRAND RAPIDS 8, MICH.
Slaughter Manufacturing Co.
3753 Division Ave., S.

INDIANAPOLIS 4, IND.
A. R. Young
635 N. Pennsylvania St.

*LOS ANGELES 21, CALIF.
J. W. Minder Chain & Gear Co.
927 Santa Fe Avenue

LOUISVILLE, KY.
Alfred Halliday, 330 Starks Bldg.

*MINNEAPOLIS 4, MINN.
Industrial Supply Co.
1100 Third Ave., South

NEW ENGLAND
George G. Pragst
P. O. Box 995, Pawtucket, R. I.

*NEW YORK 13, N. Y.
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129 Grand St.

*N. KANSAS CITY 16, MO.
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*PITTSBURGH 30, PA.
Standard Machinists Supply Co.
South 2nd and McKean Street

*PORTLAND 4, ORE.
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411 So. West First St.

*SAN FRANCISCO 3, CALIF.
Adam-Hill Co.
244-246 Ninth St.

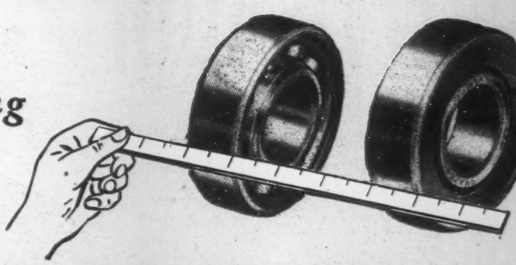
IN CANADA

*MONTREAL, CANADA
John Braidwood & Sons, Ltd.
66 Nazareth Street

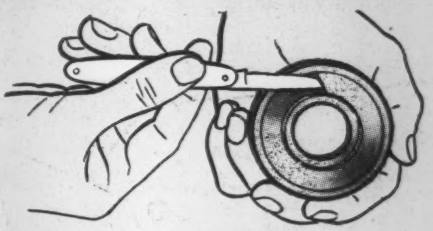
OHIO GEARS

**Stocks carried.*

It's a sealed ball bearing

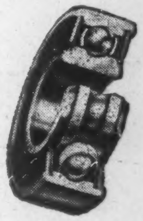


NO WIDER THAN AN UNSEALED BEARING



It's a bearing you can open
for inspection or relubrication
. . . and seal again

It's the biggest ball bearing
improvement in 20 years . . . . .



FAFNIR PLYA-SEAL

● **Tightest seal ever devised** . . . Synthetic rubber washer, locked in groove of outer ring by split retaining ring of spring steel, makes perfect contact with inner ring. Self-adjusting because pressure is constant. Absolutely non-capillary.

No distortion of rings . . . Pliable, self-adjusting character of this seal removes all possibility of out-of-roundness sometimes produced by rigid type seals.

Practically indestructible . . . Plya-Seal is unaffected by extreme temperatures up to 175°F. and beyond or down among the sub-zeros. Most ball bearing contaminants are effectively excluded. Plya-Seals in service over 5 years are still good as new. The synthetic rubber washer does not age.

Yet you can remove the PLYA-SEAL with a penknife and replace it just as easily, just as tightly . . . and you can remove and replace it as often as necessary for inspection and relubrication without reducing its efficiency in the least.

Because it's no wider than a standard unsealed ball bearing the Fafnir PLYA-SEAL offers an opportunity to add a big plus to your present machines and equipment without machining or redesigning costs. Ask your Fafnir representative to show you PLYA-SEAL, or write for full information. The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

IMPROVE Your Product Performance

LORD MFG. CO.
ERIE, PA.

BOOST PRODUCT SALES

Purchasers prefer smooth, silent operation. Lord Couplings are quiet, stop noise transmission.

AVAILABLE IN 7 SIZES

Select the exact Lord Coupling for your needs. Engineered design insures maximum torsional flexibility in each size.

LORD

Engineered FLEXIBLE COUPLINGS

DELIVER SMOOTHER POWER

Torsional vibration, drive impulses, shock loads are cushioned by flexible Lord Couplings.

PROTECT AGAINST MACHINE DAMAGE

Under *unusual* overloading Lord Couplings act as a mechanical fuse. Coupling replacement easier, cheaper than a machine.

LENGTHEN MACHINE LIFE

Lord Couplings increase service life by absorbing harmful stresses caused by misalignment, shock, vibration.

REDUCE ASSEMBLY COSTS

Extreme flexibility eliminates need for accurate shaft alignment. Compact, one-piece—easy to handle, quickly installed.

ELIMINATE PERIODIC MAINTENANCE

Lord Couplings—featuring permanently-bonded oil-resistant Neoprene—eliminate periodic inspection, lubrication. Designed for tough, dependable service.

For more information write for Bulletin 200-C

TODAY'S highly competitive markets require more than simply a price . . . superior performance is essential and often is the deciding factor that lifts product sales into mass volume—and profits.

If your product utilizes direct shaft drive for the transmission of power, then Lord *Engineered* Flexible Couplings offer an economical and definite means of enhancing product appeal.

Check the advantages above . . . *Comparison Proves Lord's Superior Design!*

The advanced soundly-engineered design of Lord Flexible Couplings is the outgrowth of a quarter-century experience in pioneering applications of Bonded Rubber Products and Vibration Control. If you have a related problem, bring it to Lord . . . our engineering and research facilities are at your service.

LORD MANUFACTURING COMPANY ERIE, PA.

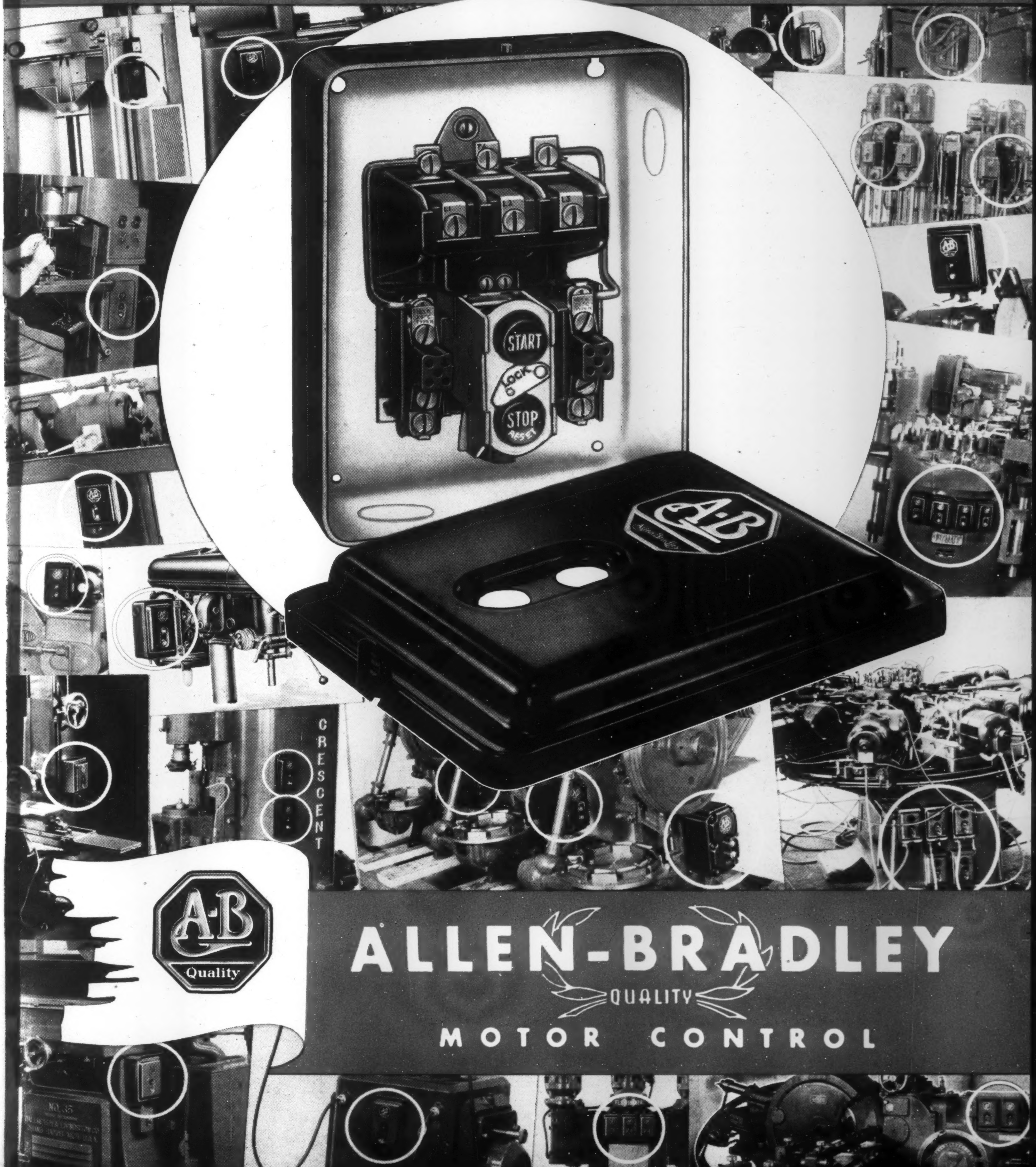
FIELD OFFICES { **New York, N.Y. Providence, R. I. Washington, D. C. Detroit, Mich. Chicago, Ill. Burbank, Cal.**

Canadian Representative: Railway & Power Engineering Corp., Ltd., Toronto, Canada.

Wichita City Library

Bulletin 609

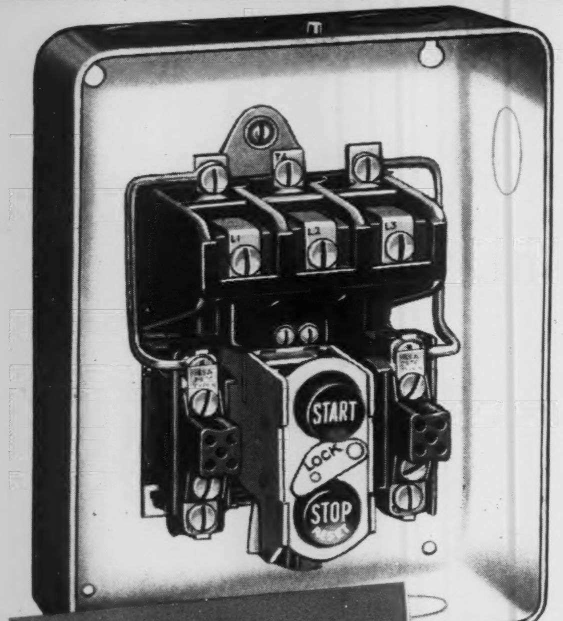
THE MOST POPULAR HAND OPERATED STARTER ON THE MARKET


START
LOCK
STOP
RESET
L1
L2
L3
A-B
Allen-Bradley
CRESCENT
NO. 35

A-B
Quality

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

BOTH GOOD FOR *MILLIONS*
OF TROUBLE-FREE OPERATIONS



DOUBLE BREAK SILVER ALLOY CONTACTS Any oxides that may form on these contacts are good electrical conductors. That's why cleaning, dressing, filing, or contact maintenance of any sort is unnecessary.

QUICK MAKE AND QUICK BREAK CONTACT ACTION The simple cam and roller switch mechanism opens and closes the contacts with a snap action. The contacts cannot be "teased." This prevents welding of the contacts and assures long contact life.

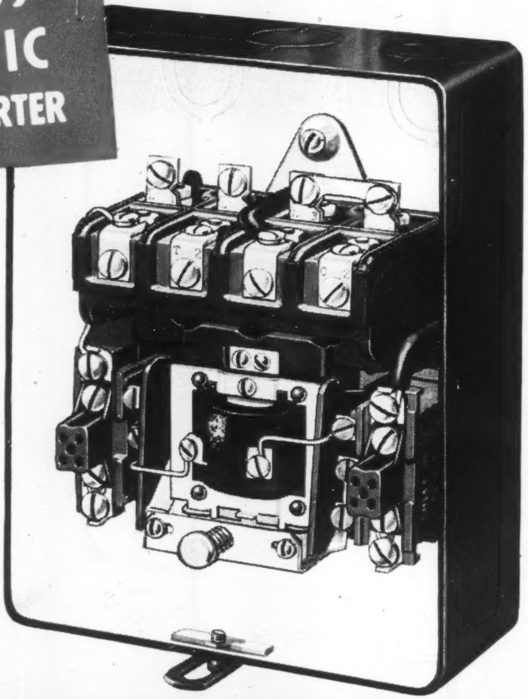
MOTOR OVERLOAD PROTECTION Two thermal breakers open the main switch contacts and protect the motor in case of sustained overloads. After they trip, pressing the "stop" button resets the overload breakers.

WHITE INTERIORS White enameled cabinet interior reflects light and illuminates the starter in dark places, making installation easy.

Bulletin 609 hand operated motor starter is the modern starter for small a-c line start motors. This ruggedly built unit will give years of trouble free operation. Push button operated. Although it is the smallest starter on the market for its rating, it has generous space for wiring.

Bulletin 609
HAND-OPERATED
MOTOR STARTER

Bulletin 709
AUTOMATIC
SOLENOID STARTER



NO CONTACT MAINTENANCE The straight line motion prevents contact rebound and practically eliminates contact welding. The double break silver alloy contacts never have to be cleaned or dressed.

EFFICIENT SOLENOID MECHANISM The solenoid magnet will operate at line voltages far below normal, assuring positive contact pressure at all times and preventing motor shutdowns when voltage regulation is bad.

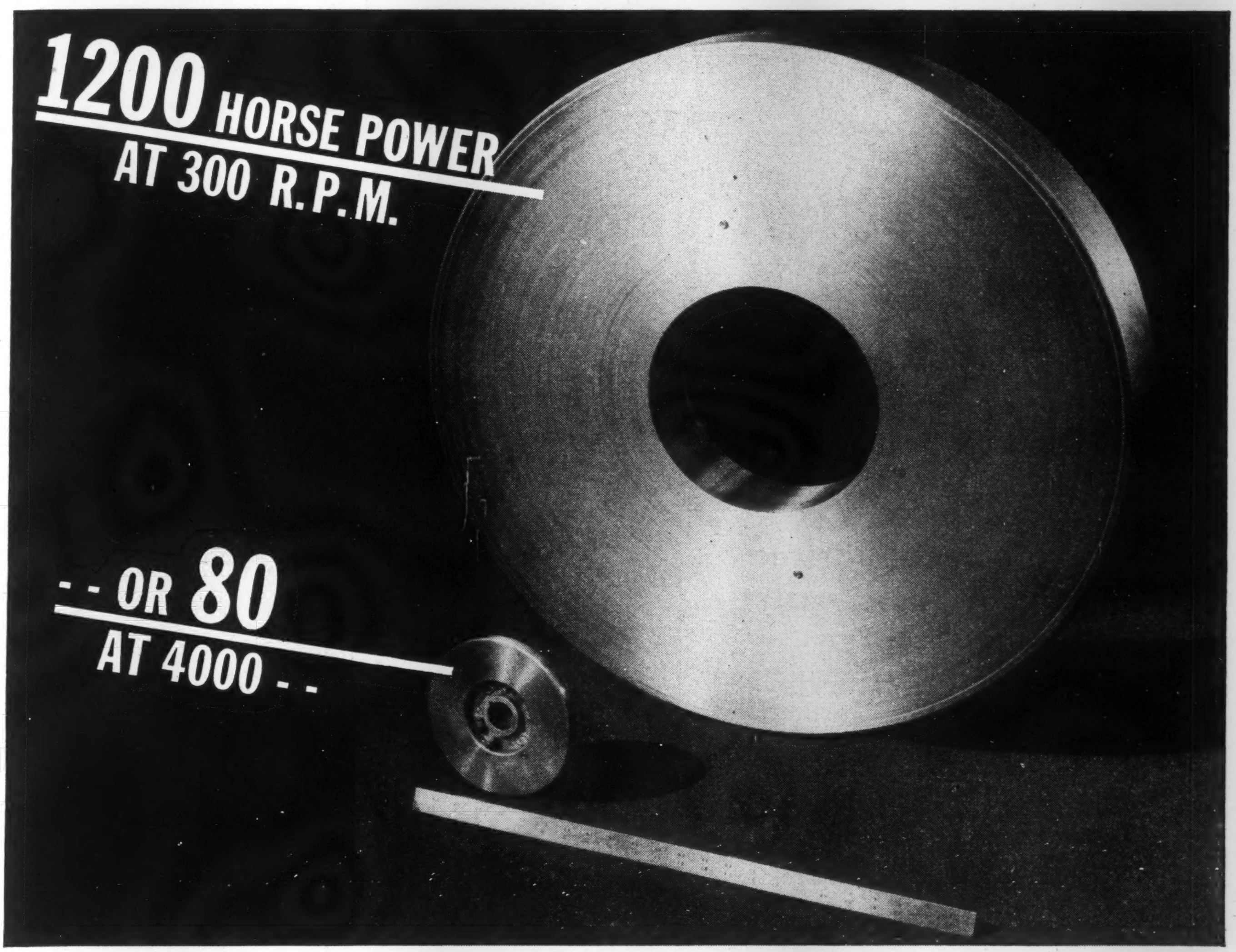
ONLY ONE MOVING PART The only moving part is the solenoid plunger which operates practically without friction. There are no pins, pivots, hinges, or bearings to gum up or corrode and cause trouble.

GENEROUS SPACE FOR WIRING The compact solenoid switch mechanism, white cabinet interior, numerous knockouts, accessible terminal connections, and removable cabinet cover combine to make installation easy.

Here's the most widely imitated starter on the market—the unit that revolutionized modern motor control design and proved its superiority under the toughest service conditions. Write for complete information, Allen-Bradley Company, 1316 S. Second St., Milwaukee 4, Wisconsin.

A-B
Quality

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL



the Houdaille* Viscous Damper

minimizes vibration efficiently

Here is the largest and smallest of the Houdaille* Viscous Torsional Vibration Dampers that have thus far been built. The one is for a slow speed, heavy duty diesel of 1200 horse power... the other for the high speed engine of a popular pleasure car.

Both of them... and the scores of others between these two extremes in size... have conclusively proven that on large engines or small, *both* major and minor critical orders of vibration can best be controlled with the Houdaille* Damper.

Since it uses a synthetic fluid with a relatively flat viscosity curve, operating efficiency is not materially affected by temperature. And since the damper is hermetically sealed and has no wearing parts, a service or replacement problem does not exist.

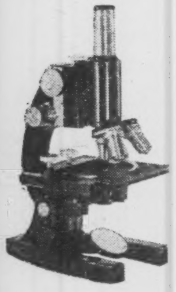
Houdaille* engineers will be glad to discuss specific applications of the Viscous Damper with any manufacturer of internal combustion engines.

An exclusive development of Houde Engineering Division. patents pending.

HOUDE ENGINEERING DIVISION OF
HOUDAILLE-HERSHEY CORPORATION
MAKERS OF HYDRAULIC CONTROLS
BUFFALO 11, NEW YORK

*Pronounced, Hoo-dye

Microscopic Accuracy ...in More Ways than One



Cutting helical pinions on Fellows 3-inch Fine-Pitch Gear Shaper. *Photos:* Courtesy Bausch & Lomb Optical Company.

PRACTICAL PRODUCTION OF FINE-PITCH INVOLUTE TEETH NOW AT THE DESIGNER'S COMMAND

The focusing adjustment of microscopes, for instance, depend upon fine-pitch helical racks and pinions whose inherent precision must relate to the high-power magnification of the optical system!

Such operating requirements impose the most severe tolerances in parallelism between the rack and pinion shown. In making such instrument parts on Fellows Gear Shapers, high accuracy and the finest of finish is more important than mass production rates. Yet, 28 sets of these racks and pinions are produced per hour with one operator.

Designers will find much of interest in our illustrated booklet "The Art of Generating With A Reciprocating Tool". A copy awaits your request. The Fellows Gear Shaper Company, Head Office and Export Dept., Springfield, Vermont. Branch Offices: 616 Fisher Bldg., Detroit 2, ... or 640 West Town Office Bldg., Chicago 12.

PRINCIPAL SPECIFICATIONS

Depth of Cut	.0358"
Pressure Angle	20°
Helix Angle	14° 30 min.
Backlash	NONE

Bearing diameter and pitch diameter of pinion must be concentric within .0001"

Pitch line and mounting surface of rack must be parallel within .0005"

Fellows

THE FELLOWS METHOD...MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR

Manufacturers of

SEALING PRODUCTS

Exclusively

thru

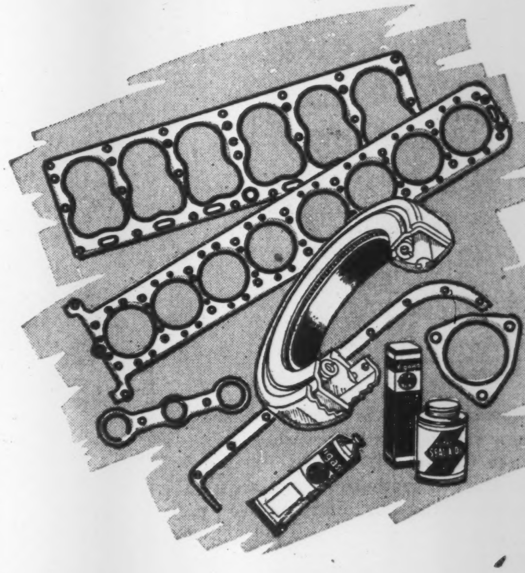
CHEMICAL RESEARCH

PRODUCT TESTING

MECHANICAL ANALYSIS

It's SEAL-OLOGY by VICTOR

that gives YOU the correct product at the lowest price



An experienced, technical staff, trained in the use of the latest types of research equipment, assures you better products at lowest prices.

Chemical research, mechanical tests and breakdown tests of completed units are used to prove new products and to improve existing products. This policy has permitted Victor to pioneer many advances in the field. Among our "firsts" is the Victoprene oil seal with the synthetic rubber sealing element. Other "firsts" are a series of advanced designs of cylinder head gaskets for internal combustion engines. More are coming.

We welcome the chance to study your problems and requirements on sealing products—gaskets, packings and oil seals. Your inquiries are invited. VICTOR MANUFACTURING & GASKET CO., P. O. Box 1333, Chicago 90, Illinois.

THE WORLD'S LARGEST GASKET MANUFACTURERS

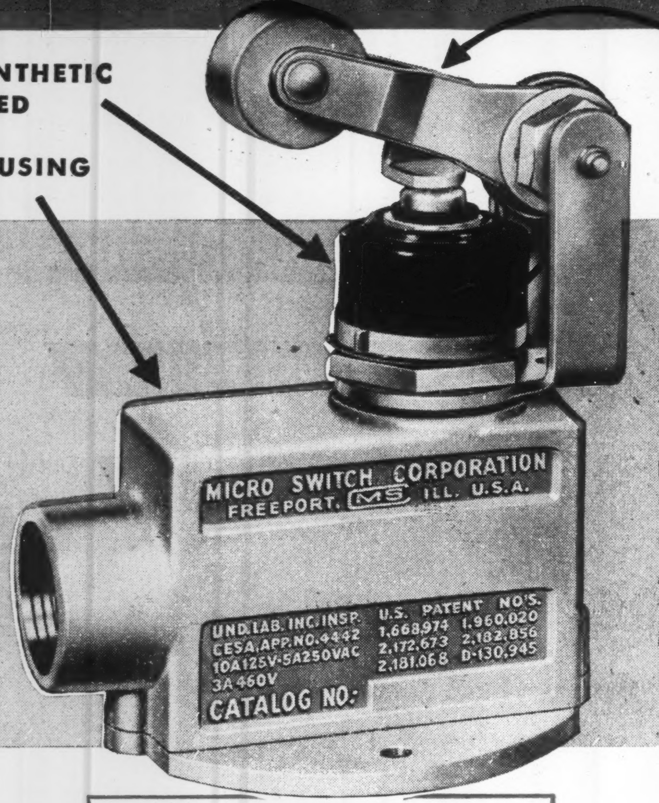
VICTOR GASKETS AND OIL SEALS

VICTOR

GASKETS • OIL SEALS

MICRO *Precision*

with Roller Arm and Synthetic Rubber Sealed Plunger – Protects Against


PLUNGER—SYNTHETIC RUBBER SEALED
DIE CAST HOUSING
ROLLER ARM ACTUATOR
MICRO SWITCH CORPORATION
FREEPORT, MS ILL. U.S.A.
UND. LAB. INC. INSP.
CESA. APP. NO. 4442
10A 125V-5A 250VAC
3A 460V
U.S. PATENT NO'S.
1,668,974 1,960,020
2,172,673 2,182,856
2,181,068 D-130,945
CATALOG NO.

CHARACTERISTICS

For use with fast cam and slide actuation and where vertical and horizontal adjustability of the arm is desirable.

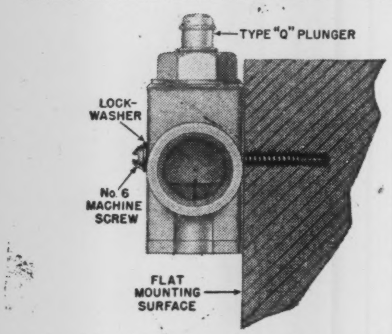
Vertically, the arm may be adjusted through any arc of 225°, and horizontally, the arm assembly can be adjusted to any of eight positions, 45° apart.

A return spring on the plunger prevents false actuation on snap-cam operation.

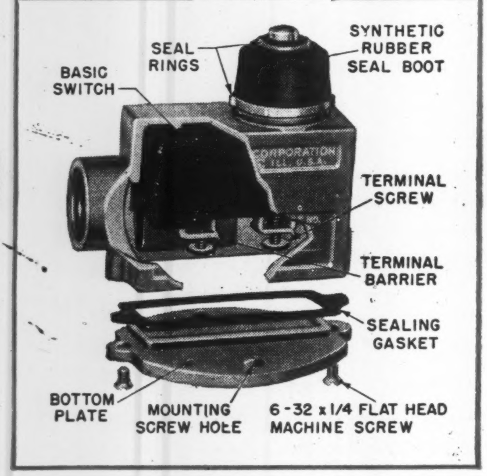
CHARACTERISTICS

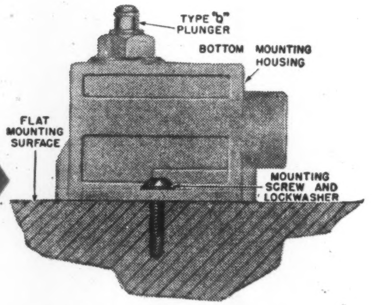
Characteristics as described below are at the roller end and at 90° angle from the arm.

Operating Force	10 to 18 oz.
Release Force	6 oz. in.
Pretravel	1/64″ max.
Overtravel	¼″ min.
Movement Differential	0.006″ min.
Net Weight	0.74 max.

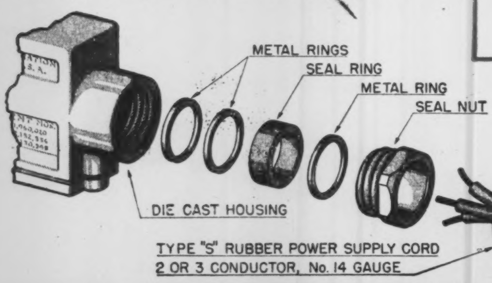

TYPE "Q" PLUNGER
LOCK-WASHER
No. 6 MACHINE SCREW
FLAT MOUNTING SURFACE

For Side Mounting. Two 6-32 x 1½″ round head machine screws with lock washers and hex nuts are furnished. Screws extend through the sides of the housing and secure housing to either a thick or thin section.


SEAL RINGS
SYNTHETIC RUBBER SEAL BOOT
BASIC SWITCH
TERMINAL SCREW
TERMINAL BARRIER
SEALING GASKET
BOTTOM PLATE
MOUNTING SCREW HOLE
6-32 x 1/4 FLAT HEAD MACHINE SCREW


TYPE "Q" PLUNGER
BOTTOM MOUNTING HOUSING
FLAT MOUNTING SURFACE
MOUNTING SCREW AND LOCKWASHER

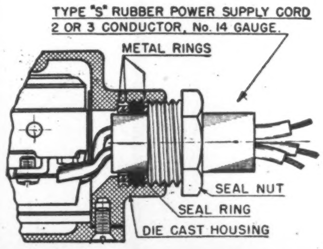
For Bottom Mounting. Provided with a ⅛″ thick flanged bottom plate. In this flange are two 11/64″ holes, one on either side of the switch housing. These accept No. 8 screws to secure switch to mounting surface.


METAL RINGS
SEAL RING
METAL RING
SEAL NUT
DIE CAST HOUSING
TYPE "S" RUBBER POWER SUPPLY CORD 2 OR 3 CONDUCTOR, No. 14 GAUGE

CONNECTING AND SEALING DEVICE

This device (which is supplied extra) should be used in combination with the sealed housing. It completely seals the switch connection against oil, water, dust and similar harmful agents. This combination, however, is not immersion proof.

The packet, known as No. 9-11444 consists of three metal rings, 1 seal ring and 1 seal nut, as illustrated.


TYPE "S" RUBBER POWER SUPPLY CORD 2 OR 3 CONDUCTOR, No. 14 GAUGE.
METAL RINGS
SEAL NUT
SEAL RING
DIE CAST HOUSING

MADE WITH THE *"KNOW-HOW"* BEHIND MILLIONS OF PRECISION SWITCHES

Die Cast Switch

Sealed Plunger... *Now Available...* Moisture, Dust and Abrasives

● The MICRO Precision Die Cast Switch with roller arm and synthetic rubber sealed plunger is introduced as a latest addition to the MICRO Switch line.

In keeping with MICRO Switch leadership of providing design engineers with the latest engineering achievements, this new switch was built to meet industrial requirements. It supplements and makes the MICRO Switch line still more complete.

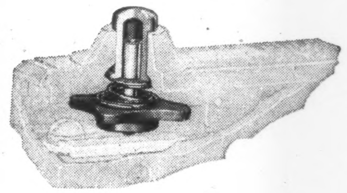
This roller arm actuated MICRO Switch is enclosed in a sturdy die-cast housing, with the plunger completely sealed by a synthetic rubber boot. A bottom-plate gasket adds a further protective seal to the switch.

This construction permits their use with complete success where equipment requires frequent washing or machinery is exposed to oil, grease, soap, fat, fruit juices or other moist conditions. The enclosure is a complete protection against dust and abrasives.

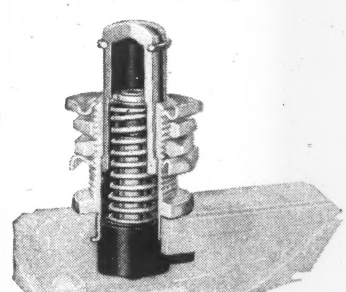
In addition to this new type switch, there are 3365 combinations of electrical characteristics, actuators and housings available to you in the MICRO Switch line. To determine the correct switch, MICRO engineers can help you. They have the "Know-How" and the wide experience in solving thousands of switching problems. Feel free to write in and ask for their aid. For convenience, many of your questions can be answered by writing the nearest MICRO Switch branch or sales representative as listed below.

The *"KNOW-HOW"* behind the manufacture of millions of switches dictates that actuators perform best when built like this...

THE "D" PLUNGER



THE "Q 1" PLUNGER



For purposes of precision, top performance, and long life—experience over a period of years and the "Know-How" gained in building millions of precision switches has proved that actuators, for top accuracy, should be an integral part of the switch.

If you are depending upon top performance, insist upon the actuator being part of the switch—don't chance a substitute method.

Here are a few examples—

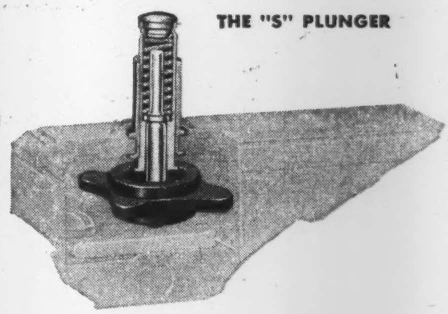
The "D" Plunger is a simple but rugged actuator well suited for use with slow moving cams, or as a mechanically actuated safety or limit switch.

The "Q1" Plunger with hardened tip moves in a threaded brass stem. 7/32" overtravel is provided by a spring mounted within the assembly.

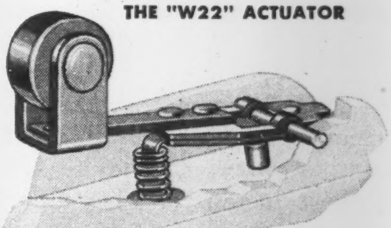
The "S" Plunger providing 1/16" overtravel has a hardened tip set in a steel sleeve to insure long life and accuracy.

The "W22" Roller Actuator provides a short lever suitable for slide or cam operation.

THE "S" PLUNGER



THE "W22" ACTUATOR



MICRO *Precision Switches*

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BRANCH OFFICES

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NEW YORK 17.........101 Park Avenue
CLEVELAND 3........4900 Euclid Avenue
LOS ANGELES 14......1709 West 8th St.
BOSTON 16.........126 Newbury Street

MICRO SWITCH
TRADE MS MARK
A DIVISION OF FIRST INDUSTRIAL CORPORATION
FREEPORT, ILLINOIS, U. S. A.

SALES REPRESENTATIVES

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DALLAS 4..........2502 McKinney Ave.
ST. LOUIS 3...........1218 Olive Street
TORONTO, Ontario, Can.....11 King Street

Timing tunes for transients

A quarter in the slot . . . and the hotel radio comes to life. The travel-weary guest can relax with exactly two hours of his favorite music. The control that times the program is operated by a Telechron synchronous electric motor.

This is only one of many applications for Telechron motors. Dependable and versatile, they have been used successfully in clocks and timing devices for 25 years—and more. New and unusual applications to automatic timing, switching, recording and control equipment are being developed constantly. Perhaps a Telechron motor is the answer to your needs.

Telechron motors are easily adapted to a wide variety of electric devices—complicated control mechanisms as well as simple switches. They're self-starting, and reach rated speed almost instantly. They operate in perfect synchronism with all commercial frequencies . . . *can't run faster or slower*. Conservative torque ratings, precision building and Telechron's exclusive oiling system assure long, trouble-free service.

A Telechron motor gives your product the extra sales advantage of Telechron leadership. For over 25 years, Telechron has been the largest producer of synchronous electric motors. Every one is Underwriters Laboratories approved. Why not let Telechron's *application engineers* study your motor needs? They'll be glad to make recommendations. Just address Motor Advisory Service, Dept. C, Telechron Inc., Ashland, Mass.

see our CATALOG in
SWEET'S FILE
for PRODUCT DESIGNERS

Telechron Motors Are Now Being Used for:

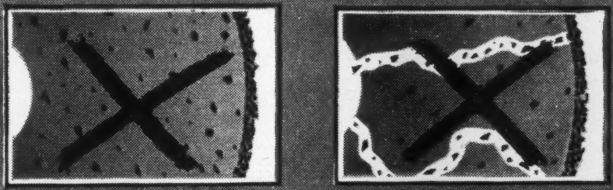
- **Stoker, Oil Burner and Temperature Controls**
- **Industrial Process and Cycling Timers**
- **Business Machinery**
- **Medical Devices**
- **Household Appliance Timers**
- **Musical Devices**

Telechron
REG. U.S. PAT. OFF.
SYNCHRONOUS MOTORS

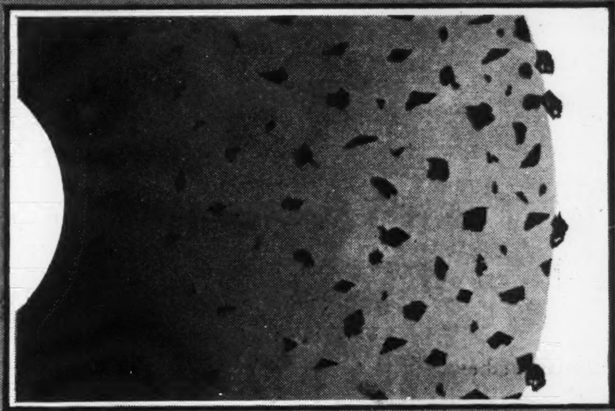
The First and Favorite Synchronous Electric Timing Motor

Before You Build In a Micronic Filter Make Sure You Understand This REVOLUTIONARY PRINCIPLE . . . It Means a

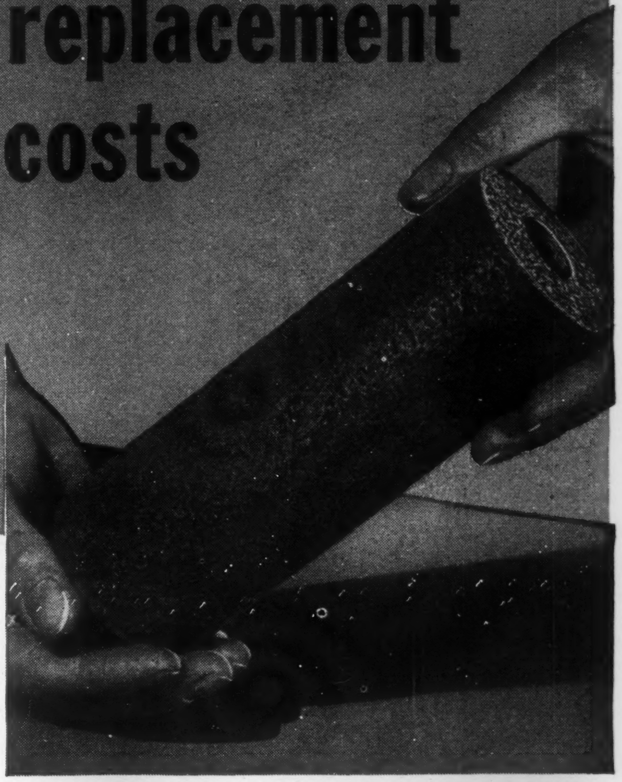
50% SAVING in cartridge replacement costs



Other depth-type filters are susceptible to surface loading and channeling. Minimum openings on pressure side cause dirt accumulation on surface — element clogs before filling. Uncontrolled distribution of filter media in element permits fluid to find channels, passing solids larger than specified.



Cross-section of MICRO-KLEAN filter cartridge. A newly-developed method of "felting" and impregnating micronic fibres creates a fibre distribution which increases in density in direction of flow. Spaces between fibres become progressively smaller and more numerous approaching discharge surface. *Graded Density in Depth* eliminates surface-loading, permits more solids of all sizes to be collected *within* the element. *Resinous Impregnation* bonds each fibre in position, preserving original fibre distribution, giving absolute protection against channeling, rupturing, shrinking, distortion.



This Filter answers your need for protecting against micronic particles *at low cost for cartridge replacement.*

Two exclusive construction features (see above) allow the Cuno MICRO-KLEAN to collect more solids before clogging — *doubling* the usual effective life.

Cuno Micro-Klean Filters Are Ideal for Built-In Installations

If you now use replaceable cartridge type filters, a trial installation of Micro-Klean filters will prove their double efficiency. Standard cartridges now available are furnished in a wide range of housing designs. Special lengths can be supplied. Write for sample cartridges for test installation.

CUNO

Fluid Conditioning

REMOVES MORE SIZES OF SOLIDS FROM MORE TYPES OF FLUIDS

AUTO-KLEAN
General service down to .0035." Disc-type. Continuously cleanable.

FLO-KLEAN
For highly abrasive solids down to .0025." Wire-Wound. Continuously cleanable.

MICRO-KLEAN
Micronic-type. Molded Fibre. "Graded Density in Depth" cuts replacement cost.

COOLANT-KLEAN
Low-cost unit filtration of grinder coolant. Fabric-type element.

SEND COUPON FOR FREE FACTS TO FIT YOUR INSTALLATION

CUNO ENGINEERING CORPORATION
201 South Vine Street, Meriden, Conn.

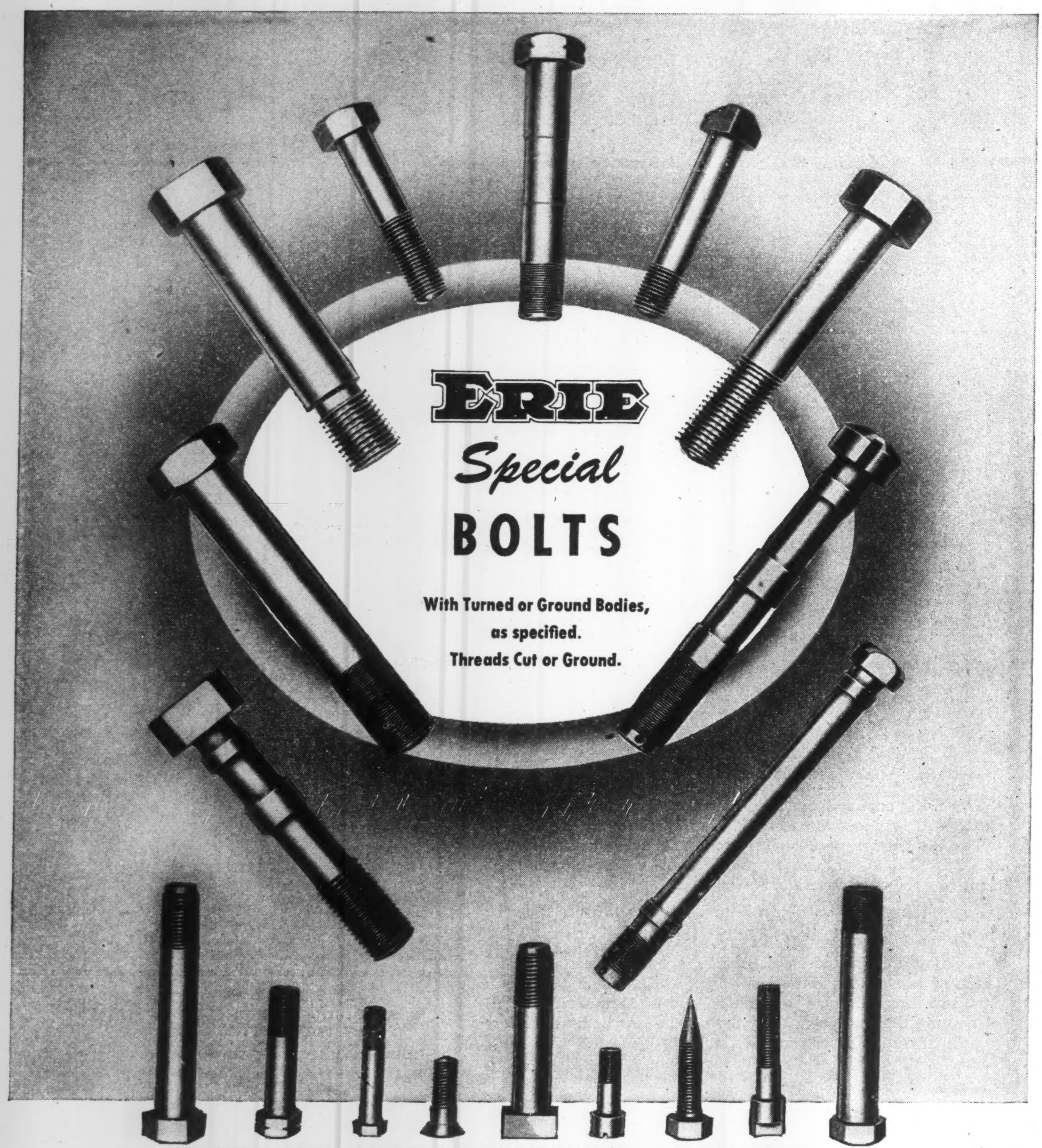
Please have nearest Cuno representative provide information relative to services checked:

☐ Lubricating Oil ☐ Water and Water Solutions ☐ Hydraulic Oil ☐ Compressed Air ☐ Fuel Oil ☐ Acids

Write any other fluid-cleaning problems here.............
....

Send free sample cartridges for: (state use)..................
....

Name..............................*Title*..............................
Company..
Address...



ERIE

Special

BOLTS

With Turned or Ground Bodies, as specified. Threads Cut or Ground.

SEND YOUR BOLTING SPECIFICATIONS TO A SPECIALIST

A dependable source of high quality bolting for Railroads, Refineries, Diesels, Farm Machinery, Excavating Equipment and all types of Heavy Machinery.

ERIE BOLT & NUT CO.
ERIE, PA.

STUDS • BOLTS • NUTS ~ ~ ALLOYS • STAINLESS • CARBON • BRONZE

BURKE'S *New Induction Motor*

RESULT OF 41 YEARS INDUCTION MOTOR EXPERIENCE

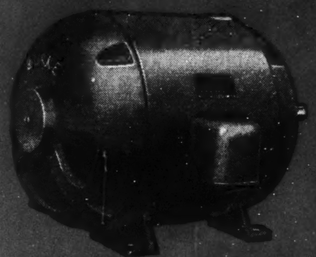
Rotor LAMINATIONS OF HIGH GRADE ELECTRICAL SHEET STEEL, SECURELY KEYED TO SHAFT SPIDER. ROTOR BARS OF HARD DRAWN COPPER STRIP FIRMLY EMBEDDED IN PARTIALLY CLOSED ROTOR SLOTS. EXTENSION OF ROTOR BARS PROVIDES AMPLE FAN ACTION FOR EFFICIENT VENTILATION.

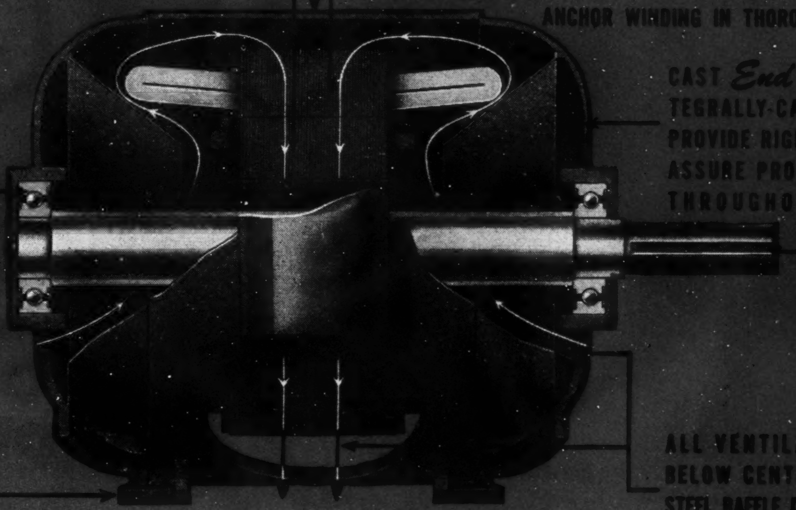
Frame OF ROLLED, WELDED STEEL FOR GREATEST RIGIDITY WITH MINIMUM BULK AND WEIGHT.

Stator CORE, OF HIGH GRADE ELECTRICAL SHEET STEEL, IS INDEPENDENT OF SUPPORTING FRAME; AND RIGIDLY WELDED INTO PLACE TO MAINTAIN PERFECT ALIGNMENT. STATOR COILS ARE WOUND WITH NEW SYNTHETIC RESIN-COVERED WIRE PROVIDING EXCELLENT DIELECTRIC STRENGTH AND MAXIMUM EFFICIENCY. FIBRE WEDGES SECURELY ANCHOR WINDING IN THOROUGHLY INSULATED SLOTS.

Ball Bearings ARE OF DOUBLE SEAL, PRE-LUBRICATED TYPE. NO FURTHER LUBRICATION NECESSARY DURING NORMAL LIFE OF MOTOR. PRESS FIT ON SHAFT ELIMINATES NEED OF LOCK NUTS AND WASHERS. SLEEVE BEARINGS ALSO AVAILABLE.

CAST ***End Brackets*** WITH INTEGRALLY-CAST BEARING HOUSINGS PROVIDE RIGID SUPPORT FOR ROTOR, ASSURE PROPER SHAFT ALIGNMENT THROUGHOUT LIFE OF MOTOR.





COMPLETE ROTOR IS DYNAMICALLY BALANCED AFTER ASSEMBLY TO GUARANTEE SMOOTH, QUIET OPERATION.

HEAVY, CROSS-WELDED, FORMED STEEL FEET PROVIDE FIRM MOUNTING SUPPORT.

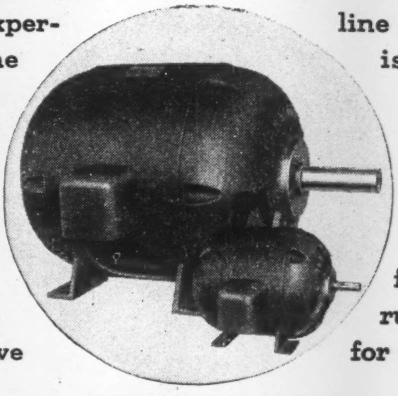
ALL VENTILATING OPENINGS ARE BELOW CENTERLINE. STURDY SHEET STEEL BAFFLE DIRECTS FLOW OF INCOMING AIR FOR MAXIMUM COOLING EFFECT.

CROSS SECTION VIEW OF BURKE TYPE NB INDUCTION MOTOR, FRAME 404

Burke Series "D" NEMA Frame Sizes 203 to 505.

Burke's new line of Drip-Proof Induction Motors follows our traditional policy of designing to generous proportions. We have achieved the utmost from NEMA frame standards utilizing over 30 years experience with welded steel plate frame construction. We have not tried to confine component parts into minimum space. As in all Burke motors we have designed for a generous factor of safety.

These Series "D" Motors on exhaustive tests in our plant have fully justified our generous-proportion-theory—they run exceptionally cool over extended periods of service. Note above that cooling air enters at each end below the centerline induced by rotor fan action, and is deflected up and down and around motor windings leaving thru large side openings between feet and below the centerline—no chance for recirculation. Here ample interior space for air-flow contributes to cool running. Write for bulletin D-1 for complete data.



Uniform in design from NEMA frame sizes 203 to 505.

BURKE ELECTRIC COMPANY 1974 W. 12th ST. ERIE, PA.

UNIVERSAL MOTORS [illegible]

SINGLE PHASE MOTORS to ½ HP

INDUCTION MOTORS 1 to [illegible] HP

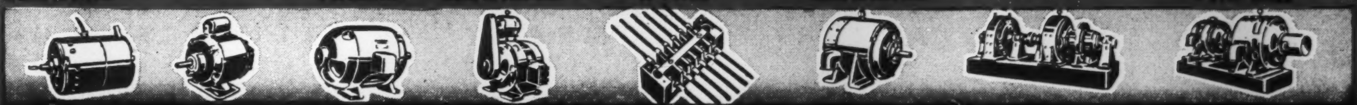
SYNCHRONOUS MOTORS to 1500 HP [illegible]

TERMINAL BLOCKS [illegible] TYPES

D. C. MOTORS to 1500 HP [illegible]

M-G SETS to 2000 Kw.

HIGH CYCLE M-G SETS— [illegible]



GET SET FOR COMPETITION

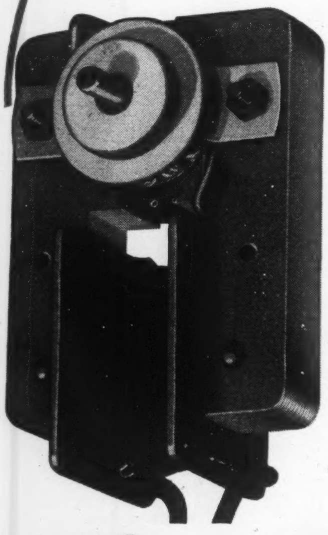
USE alliance MOTORS

Alliance Powr-Pakt Model MS motor is for 110 volts, 60 cycle operation. Model MS fills a growing need for small compact motors which increase the *motion* and *utility features* in thousands of new products.

For the designs of tomorrow, *Alliance Motors* mass produced at low unit cost, will be built with design variations to meet special small load operating conditions. They'll actuate controls, trip switches, move levers, cams and valves . . . perform thousands of tasks that require power at specific points!

Drive your products to market—use *Alliance Motors* to drive vital component parts. Big advantages for the Alliance Powr-Pakt line are compactness, light weight, versatile performance characteristics, and *mass production* at low cost.

Alliance Powr-Pakt Motors are rated from less than 1/400th h.p. on up to 1/20th h.p. They'll supply just the *right amount of power at strategic points* to impart automatic action, instant control and greater usefulness for your products and processes.



MODEL MS

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

5

REVERE METALS

Meet Strict Lock Requirements

★ ★ ★

Here is an example of the manner in which the wide variety of Revere Metals permits exact specification. In the manufacture of this lock *five* Revere Metals are employed. Here they are:

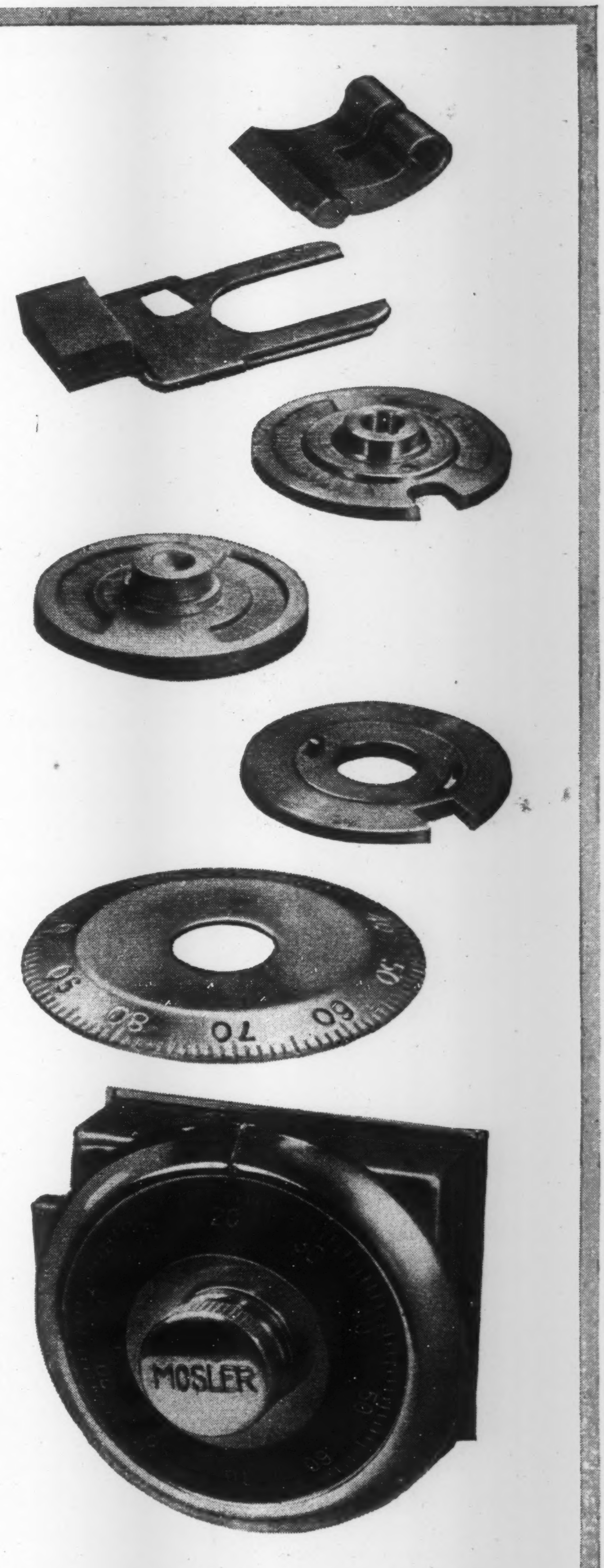
1. **70-30 Cartridge Brass for the dial flange**
2. **Commercial Bronze, 90%, for case, case lid and bolt**
3. **Heavy Leaded Brass for tumbler parts and other items, including dial, requiring exceptionally accurate machining**
4. **Free Cutting Brass in Rod and Extruded Shape, for the machined and knurled head, and for the angle bar**
5. **Forging Rod, for the tumbler driver**

Selection and employment of these metals enabled the manufacturer to meet the many different requirements of fabrication methods, and at the same time assure strength, long life and reliable operation. Revere Metals perhaps can do as much for your own product. For cooperation in the choice and use of these metals, ask about the Revere Technical Advisory Service. Revere supplies mill products as follows: *Copper and Copper Alloys:* Sheet and Plate, Roll and Strip, Rod and Bar, Tube and Pipe, Extruded Shapes, Forgings—*Aluminum Alloys:* Tube, Extruded Shapes, Forgings—*Magnesium Alloys:* Sheet and Plate, Rod and Bar, Tube, Extruded Shapes, Forgings.

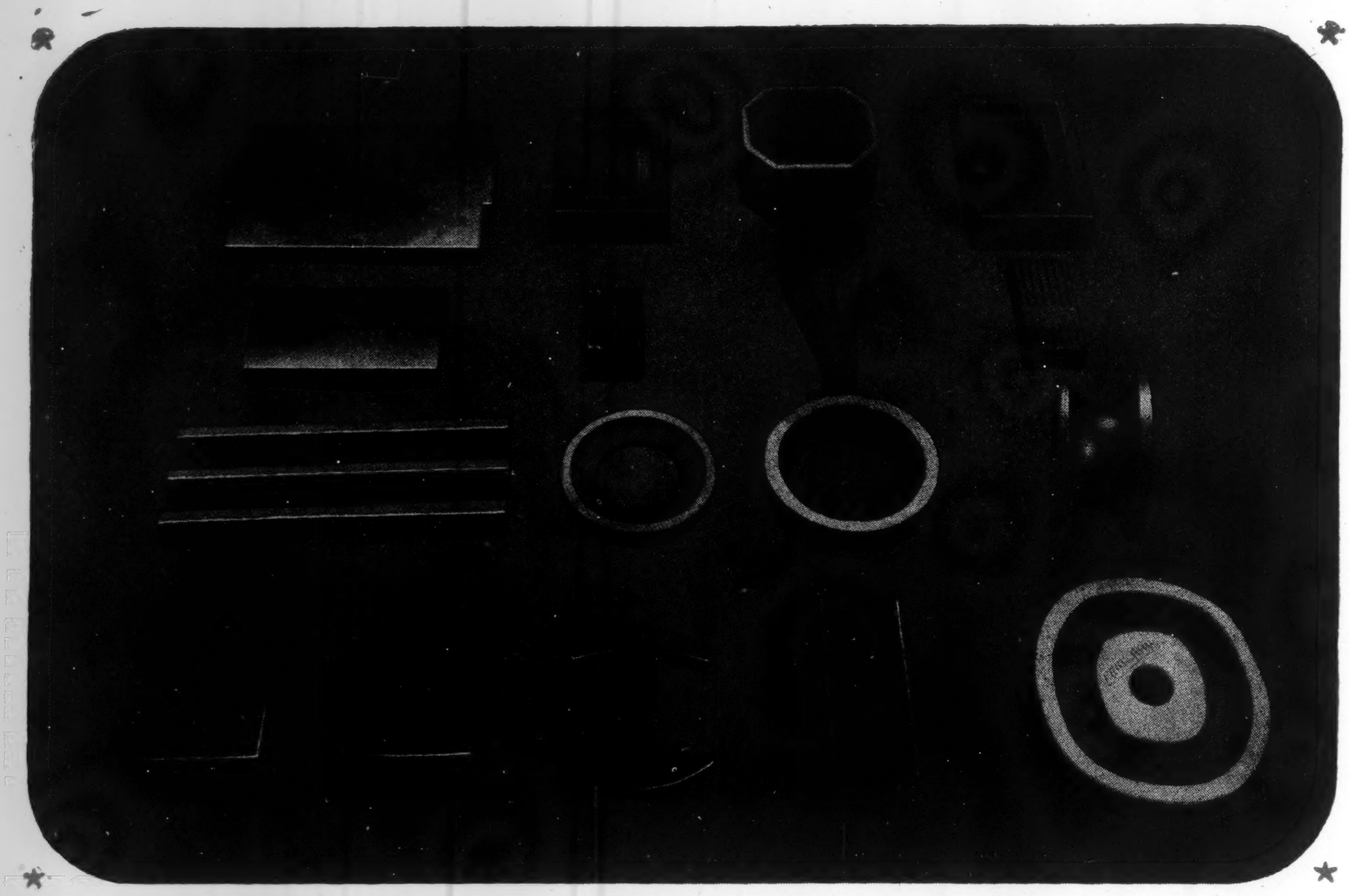
REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801
230 Park Avenue, New York 17, New York
Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.



Mosler combination lock, most of its parts fabricated of Revere Metals. Made by The Mosler Lock Company, Covington, Ky., the lock manufacturing division of The Mosler Safe Company, largest builders of safes and vaults in the world.



START WITH YOUR JOB *Half Finished*

Write for New Booklet:

CAST-TO-SHAPE TOOL STEEL

Gives you full details on FCC Air Hardening, Oil Hardening and other Cast-To-Shape Tool Steel Specialties capable of saving you time and money.

Get Your Copy—Write for it Today

ADDRESS DEPT. MD-52

WHEN it's dies you're making—small or large—or various other forming tools or gages or certain fast-wearing parts of machines, FCC Tool Steel *Cast-To-Shape* can really save you money.

Very intricate shapes can now be cast in one piece within an eighth-inch of finished size. This means that you pay for less steel to begin with, and reduce machining time substantially.

Air Hardening, Oil Hardening and special Hot Work Tool Steels of various grades—each a thoroughly dependable performer in its class—are promptly available in this modern, economical form.

Any Allegheny Ludlum branch office can give you full particulars, or write for data.

ALLEGHENY LUDLUM

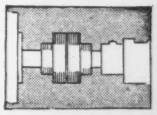
STEEL CORPORATION

Forging and Casting Division

Detroit 20, Michigan

W & D 564

AJAX

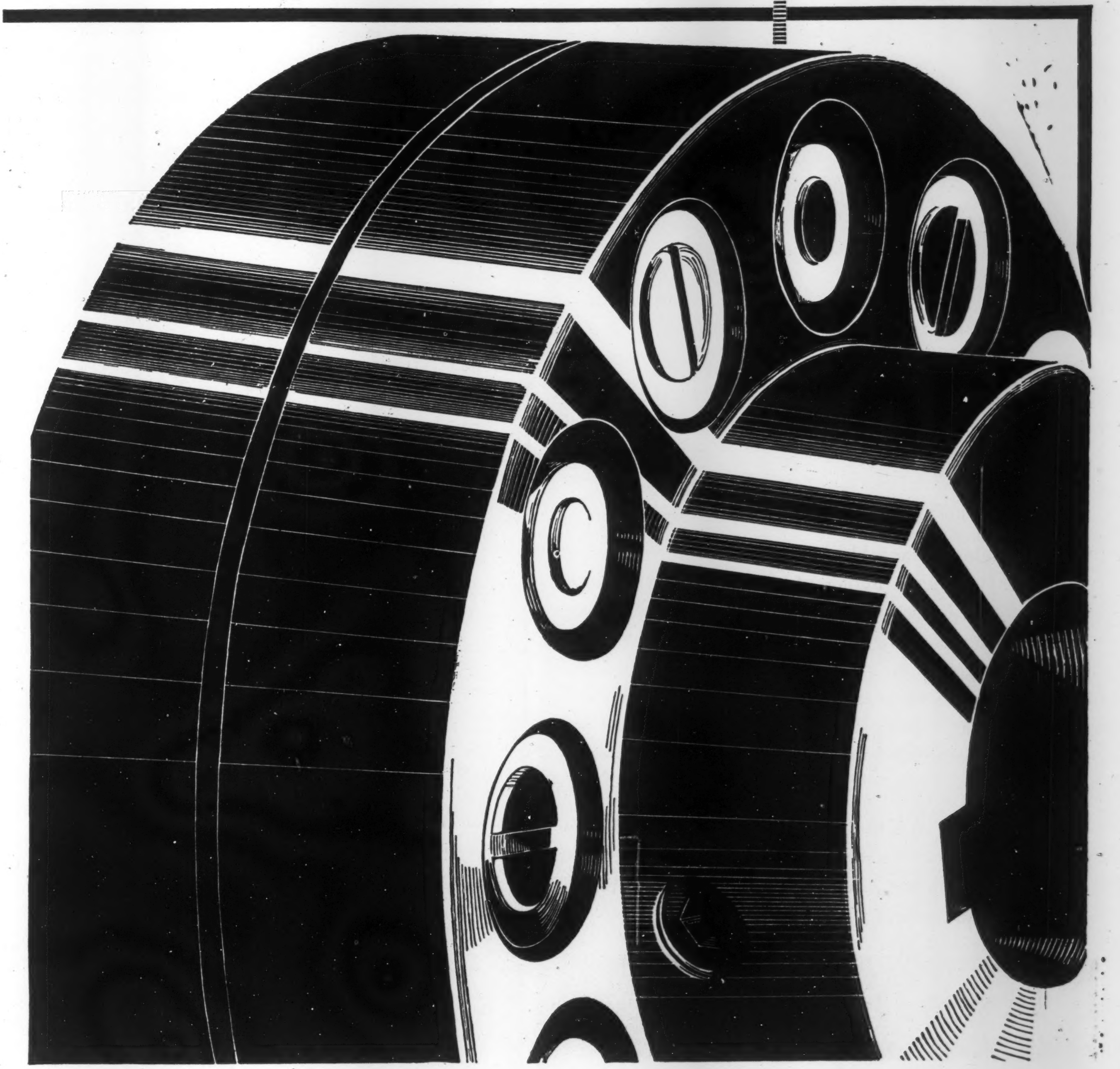


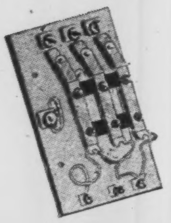
flexible COUPLINGS

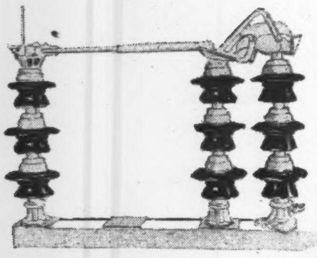
Design engineers have been writing Ajax Flexible Couplings into the specifications of direct-connected machines for over 25 years. Quiet running . . . no lubrication . . . free end-float . . . operate horizontally or vertically . . . can be made integral with fly-wheels, pulleys, brake drums, etc.

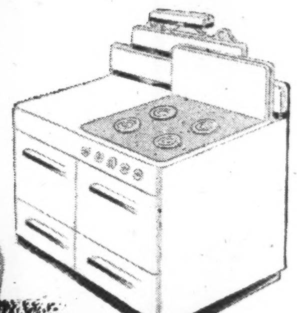
They safeguard against unavoidable misalignment. Write for data book.

AJAX
FLEXIBLE
COUPLING CO. INC.
WESTFIELD, N. Y.







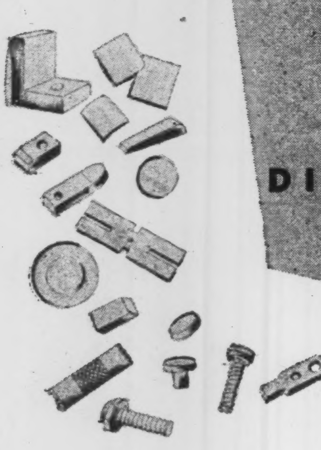


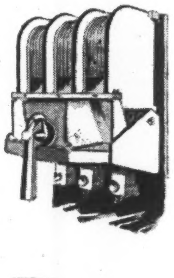
FROM MIDGET RELAYS TO CIRCUIT BREAKERS

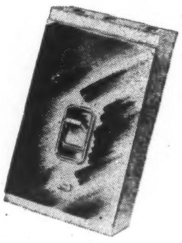
Gibsiloy

ELECTRICAL CONTACTS

MEET MANY DIVERSE APPLICATIONS







THE application of contact materials is an engineering problem in which the circuit conditions and mechanical characteristics of the device must be expertly evaluated. While it is difficult to generalize, the table at the right shows some typical applications of Gibsiloy contact materials.

Each heading in the table (except fine silver) represents a group of contact materials of the general composition indicated. Within each group are several specific grades having specific compositions and electrical and mechanical properties. Thus gradations of characteristics are obtained. Because of the wide selection of materials thus available, materials having an appropriate combination of electrical and mechanical characteristics may be selected for specific applications.

For a detailed analysis and specific recommendations for your contact application write for data sheets. They will save you time and help you answer all questions relative to specifying electrical contacts.

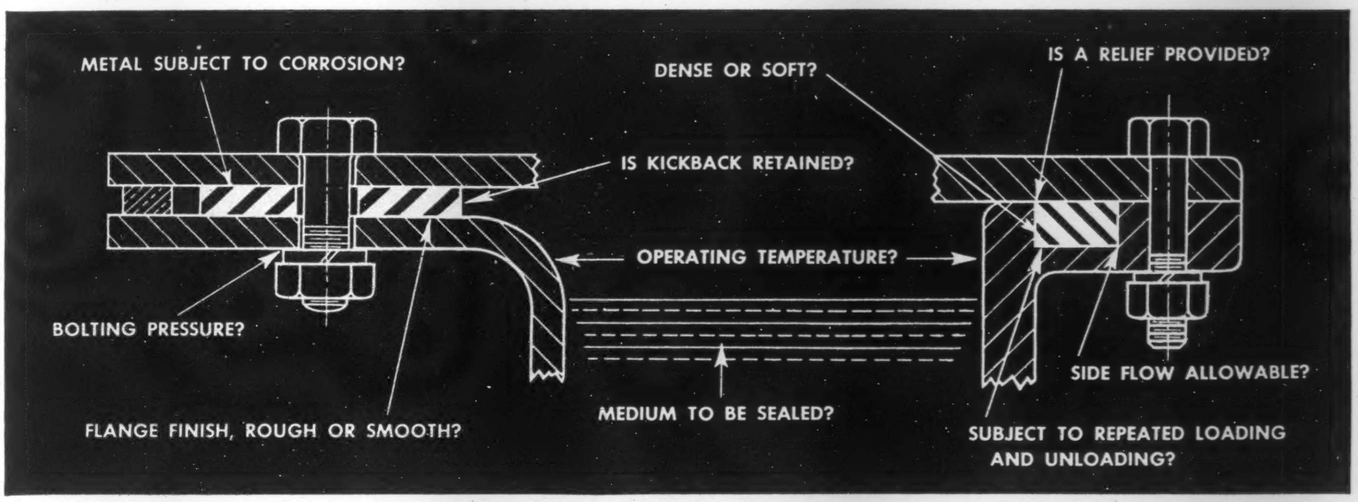
Gibsiloy
ELECTRICAL CONTACTS

Manufactured by
GIBSON ELECTRIC COMPANY
8355 Frankstown Ave., Pittsburgh 21, Pa.

Typical Contact Applications

CONTACT MATERIALS	Silver-Tungsten	Silver-Nickel	Silver-Graphite	Silver Alloys	Fine Silver
RANGE of CONDUCTIVITY* (% IACS)	30-50	64-100	60-70	14-88	106
APPLICATIONS					
Circuit Breaker Contacts					
Make and Break Contacts	X	X	X		
Current Carrying Contacts		X			
Arcing Tips	X				
Coin Operated Devices		X		X	X
Contactors	X	X	X		
Disconnect Switches		X			
Domestic Appliances		X			X
Limit Switches		X			X
Motor Controls					
Light and Medium Duty		X	X		X
Heavy Duty	X	X	X		
Relays					
General	X	X	X	X	X
Sensitive		X		X	X
Heavy Duty	X	X	X		
Rheostats		X	X		
Thermostatic Controls		X		X	X
Transformer Tap Changers	X	X			

**The ranges of conductivity are for the groups of materials indicated. The conductivity of a particular grade of material is accurately maintained within very narrow limits.*



FACTORS IN CHOOSING RESILIENT GASKETS

Final selection speeded by analyzing operating conditions, material characteristics

Once a good flange or joint design has been developed, there remains the problem of choosing a specific gasket material. A review of the principal factors to be considered can help narrow the range of possible choices and speed final selection.

TEMPERATURE. Temperatures in excess of 250° F. immediately eliminate most resilient gasketing materials. Where temperatures fluctuate, an average figure may be used as the upper limit. Surges to temperatures in excess of 250° ordinarily are not fatal if they are infrequent and of short duration.

INTERNAL PRESSURE. When internal pressures are high, a tough, non-porous material should be used. Gaskets normally should be as thin as flange surfaces will permit. In addition, special groove or flange design may be required.

MEDIUM TO BE SEALED. When a gas or fluid must be sealed, its effect on the gasket must be determined. For example, a gasket may be made ineffective by a fluid that partially dissolves it or brings out certain extractables. Some fluids may harden a gasket or otherwise affect its aging qualities. As a further example, the presence of steam, acids, or alkalies will eliminate certain resilient materials. On the other hand, the fluid itself may be contaminated by elements dissolved out of a gasket.

Along with a consideration of operating conditions must go an appraisal of the various gasketing materials and their characteristics.

COMPRESSIBILITY. A soft, highly compressible material is required for semi-finished or irregular surfaces, such as stamped flanges, and joints where only light bolting pressures are available. Such a material is needed also in confined application where no side flow is allowable. Harder, less compressible materials normally should be used on heavy, smooth flanges that provide substantial bolting pressure.

KICKBACK. Closely related to compressibility is kickback, the ability of a material to maintain effective pressure against sealed surfaces. Retention of kickback is essential to a lasting, tight seal. Accordingly, the reaction of each possible material to the operating conditions must be known and also its behavior under repeated loadings and unloadings, if such usage is involved. Continuous loading will, of course, produce a permanent set in most resilient materials. A good gasket material, however, will reach a point of equilibrium in this respect and still retain enough kickback to insure a tight seal.

CORROSIVE PROPERTIES. Where corrosion enters, as when sealing any of the light metals, gasket materials treated to prevent undesirable reactions or compounded especially for this service must be used.

* * *

Since so many variables influence the choice of a gasket material, we recommend that you discuss your particular application with an Armstrong representative before you set up a specification. He will be glad to suggest suitable materials and supply samples for testing. Call or write the district office nearest you.

If you prefer, send drawings and details to us for review. You will find our recommendations unbiased and keyed to good current gasketing practice. There's no obligation, of course.

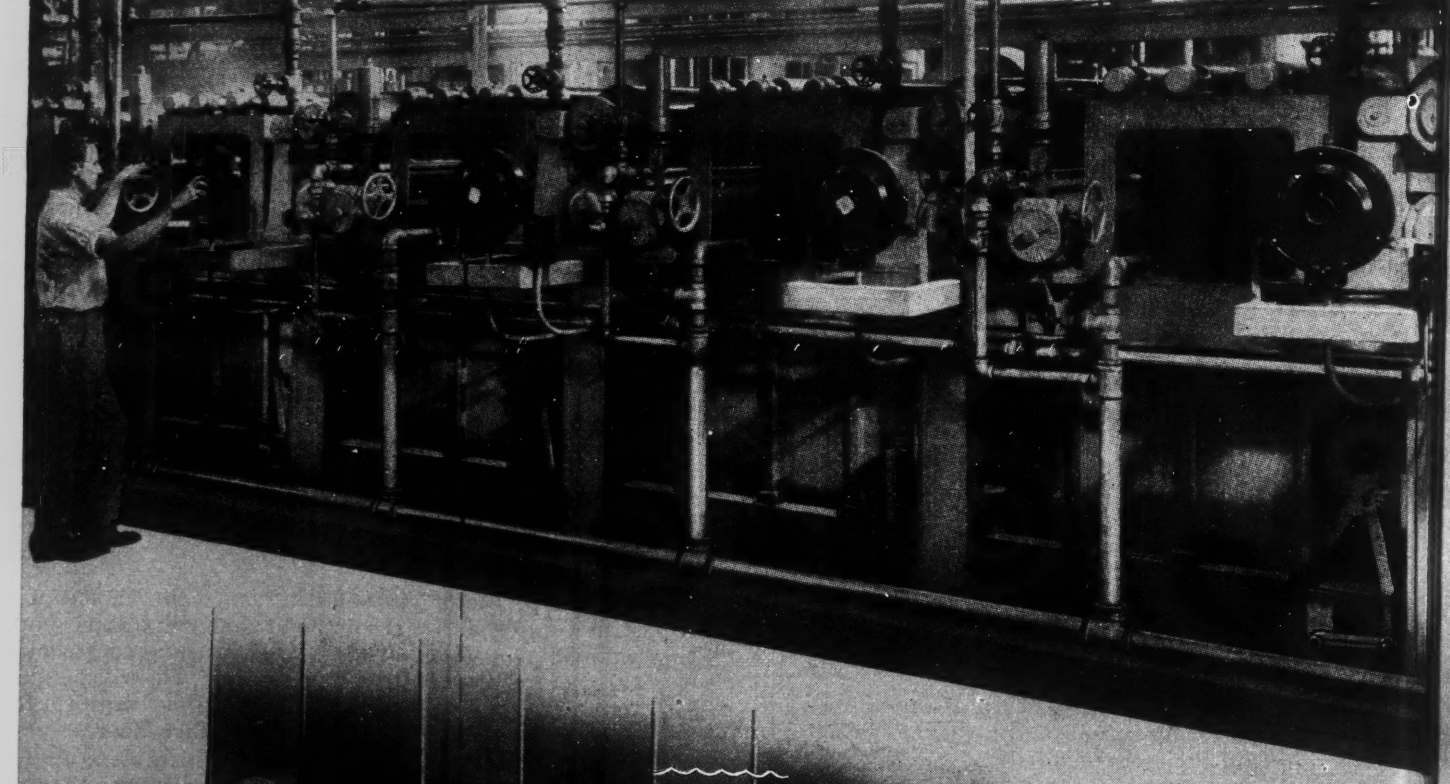
ARMSTRONG'S

SEND FOR FREE BOOKLET.

For specification and application data on Armstrong's more than 50 resilient sealing materials, send for a free copy of the latest edition of "Gaskets, Packings, and Seals," twelve pages of helpful information. Address Armstrong Cork Company, Gaskets and Packings Department, 5104 Arch Street, Lancaster, Penna.

ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Cork Compositions • Cork-and-Synthetic-Rubber Compositions
Synthetic Rubber Compounds • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork


No wear,
graphitar
(CARBON-GRAPHITE)
PROVES IDEAL MATERIAL FOR BEARINGS
IMMERSED IN DYE VAT
THE UNITED STATES GRAPHITE

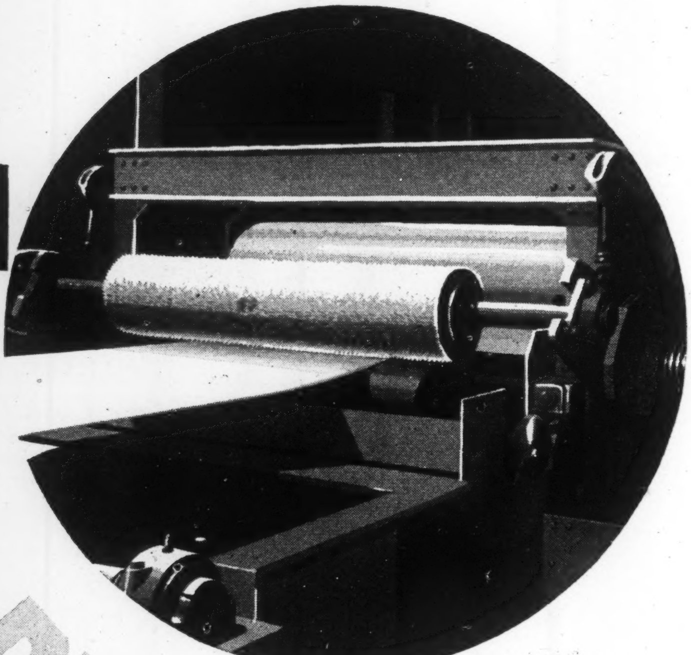
no corrosion, chemically inert Graphitar Bearings play large part in trouble-free operation of H. W. Butterworth & Sons Vat Bleaching and Dyeing Machinery

Acids and strong alkali solutions that corrode conventional bearing materials have no effect on Graphitar . . . because Graphitar is chemically inert. That's why engineers of the H. W. Butterworth & Sons Co. of Philadelphia, manufacturers of finishing machinery, specify Graphitar bearings for the submerged rollers in their vat dyeing and bleaching ranges that are known throughout the textile industry for their dependability. Although completely submerged in corrosive dyes and bleaches, the Graphitar bearings dependably resist chemical attack and assure smooth, uninterrupted operation for the rollers that carry fabrics through the finishing process. In fact, these bearings are lubricated by the solution in which they are submerged, hence require no maintenance.

Graphitar Bearings, Seals, Bushings cut maintenance and improve operation of scores of products and machines

Chemical inertness is only one of Graphitar's many characteristics that make this unusual carbon-graphite composition the ideal material for bearings, seals, bushings, and other parts for pumps, compressors, torque converters, and scores of different type mechanisms. Graphitar is mechanically strong. It will not melt or fuse at any temperature. It is self-lubricating. We are equipped to produce Graphitar parts in any practical shape and to tolerances as close as .0005" in small sizes. Send us sketches or descriptions of your products and we will be glad to recommend the use of Graphitar parts where they will improve mechanical performance and save you money. Ask for 44-page catalog.

COMPANY • SAGINAW, MICHIGAN



How to give a cold rolled strip the BRUSH-OFF

● A characteristic problem of cold roll strip production is the removal of oil and other foreign matter. Pittsburgh has solved this by a 3-color, dense filled, medium stiff brush. This special brush of even trim, spiral wound, removes all rolling oil and other foreign matter after the strip has passed through a heated alkaline bath and been sprayed by clear water.

Such a brush has to take plenty of punishment for it is constantly subjected to both the softening effect of water and rapid friction of the strip. Brushes by Pittsburgh are skillfully and durably built to withstand this heavy going.

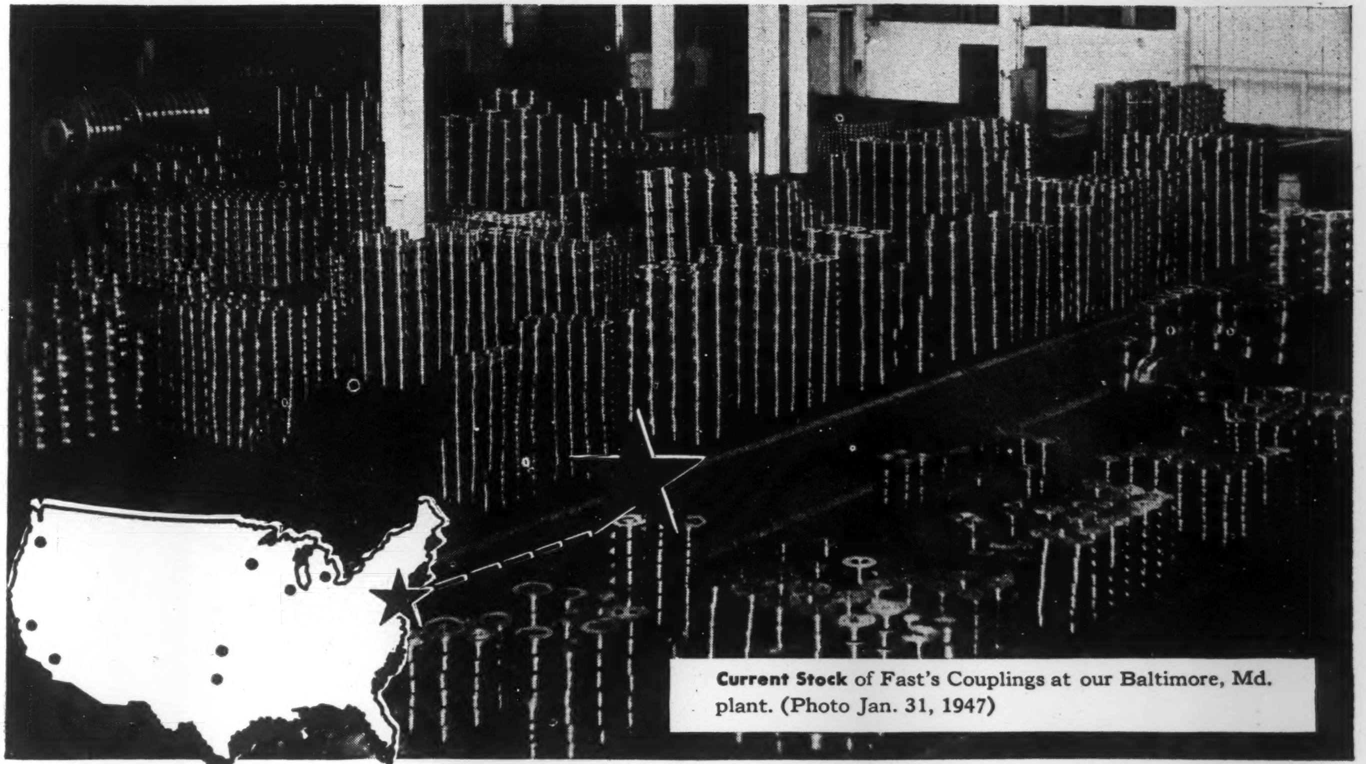
Why the Pittsburgh Plate Glass Company Makes Brushes

As a leading manufacturer of paints, Pittsburgh found that a reliable source of quality brushes was necessary for the proper application of its products. For over 40 years, Pittsburgh has made its own paint brushes. It was a natural step to extend its engineering and manufacturing facilities by developing production, maintenance and power-driven brushes engineered to the specific needs of industry.

It pays to use power-driven brushes by Pittsburgh

● You can depend on Brushes by Pittsburgh for top performance, enduring economy, and a minimum of lost time in changeovers. In the complete Pittsburgh line are brushes of all types, including "Perfect Balance" sections, wheels and section assemblies, Uni-Fill scratch brushes, as well as paint and other maintenance brushes. ● Consult the Pittsburgh engineering representative. He will gladly work with you in developing any type of power-driven brushes to meet your particular finishing requirements.

PITTSBURGH
PLATE GLASS COMPANY *Brush Division*
3221 FREDERICK AVENUE · BALTIMORE—29 · MARYLAND

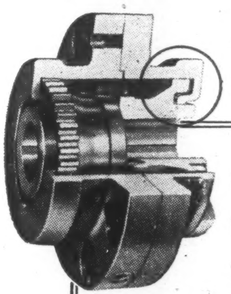

Current Stock of Fast's Couplings at our Baltimore, Md. plant. (Photo Jan. 31, 1947)

In Emergency, *Immediate* Delivery on FAST'S Couplings

Our usual prompt service on couplings can be stepped up in an emergency. Shutdowns cost money and it is important to remember that Fast's Couplings can be supplied fast—*usually immediately* in an emergency.

We can back up this promise because we maintain a large stock of Fast's Couplings at Baltimore, Maryland, service stocks at Chicago, Illinois . . . Minneapolis, Minnesota . . . Detroit, Michigan . . . and complete stocks at Portland, Oregon . . . San Francisco, California . . . Los Angeles, California . . . Tulsa, Oklahoma . . . and Fort Worth, Texas.

When you specify Fast's Couplings, you can count on them being delivered when you want them. Write . . . wire . . . or phone today to: Koppers Company, Inc., Fast's Coupling Dept., 254 Scott Street, Baltimore 3, Maryland.

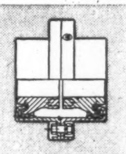


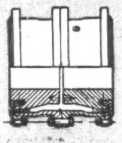
Only FAST'S Gives You this Extra Protection

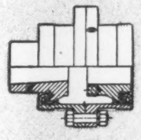
The *exclusive* "rocking bearing," shown in the circle, is one more reason for ordering Fast's Couplings, *now*. It provides a positive metal-to-metal seal to guard the load-carrying oil against moisture, dust and grit. Note that *no* perishable packing rings are used.

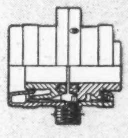
KOPPERS

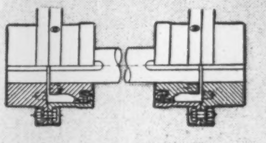
FAST'S
self-aligning
COUPLINGS


Light Duty

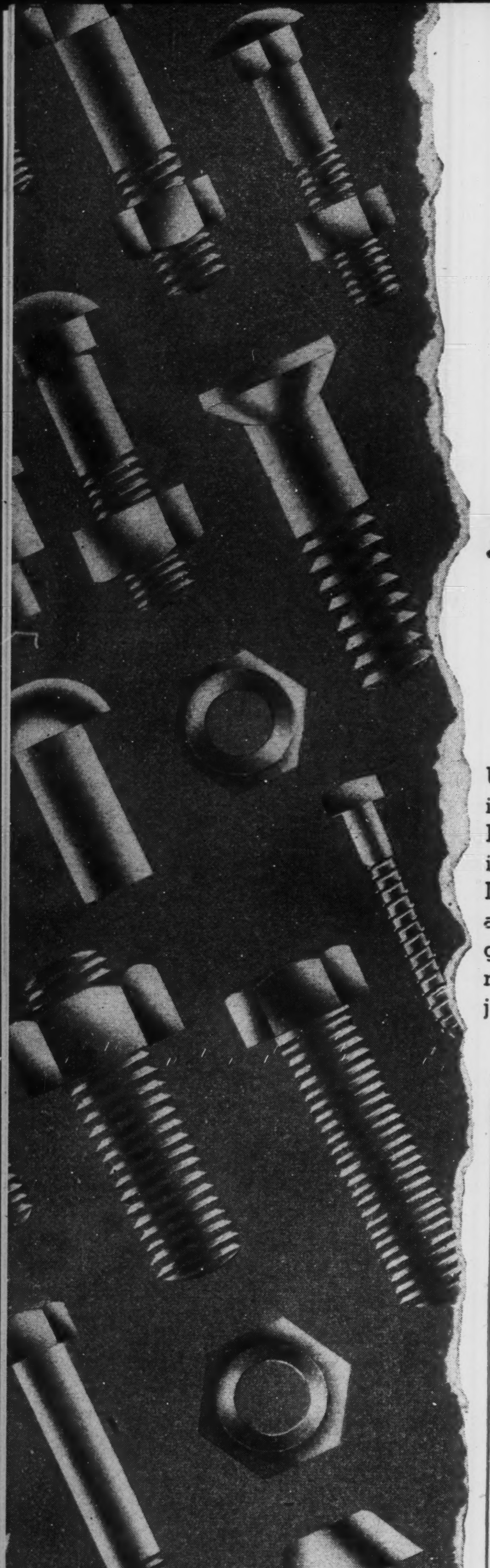

Heavy Duty


Mill Motor


Cut-Out


Floating Shaft

OTHER TYPES:
Jordan
Single Engagement
Shear Pin
Breaking Pin
Continuous Lubricating
Collector Ring
Vertical



A FREE TECHNICAL PERIODICAL

for

Engineers · Designers Production Men...

Up-to-date application and engineering data is available to you in FASTENERS, issued at regular intervals by the American Institute of Bolt, Nut and Rivet Manufacturers. This useful publication will be sent free to anyone interested in the subject. Our object in publishing this booklet is to help users of Industrial Fasteners apply them properly, effectively and economically. Its articles are authoritative, to the point and well illustrated. It contains engineering data based upon recent research (see below). If you are not already receiving FASTENERS, or if some of your associates should be getting it, just fill-in and mail the coupon below, and it will be sent at no cost.

REPRESENTATIVE ARTICLES PUBLISHED IN FASTENERS

How Tight Should A Bolt Be? . . . an engineering discussion of the strength of highly stressed, dynamically loaded bolts and studs . . .

Clamping Force—The Silent Partner in Riveted-Joint Dependability . . . clamping force in hot-driven riveted joints provides resistance to slip . . .

Screw Threads for High Temperature Bolting . . . as oil refineries, steam power plants and similar industrial processes adopt higher temperatures, high temperature bolting becomes an important problem.

Metal Fastenings in Wood Construction . . . thousands of tests and observations of actual performance have developed basic engineering data for the application of fasteners . . .

Repeated Loads on Riveted Joints . . . static load tests cannot give the information that is made available by a fatigue machine . . .

Rivets and Bolts in Structural Design . . . important changes in the use of structural bolts and rivets will probably result from recent revisions of AISC and ASTM specifications which are discussed . . .

Standard Irregular or Special . . . the manufacturing equipment which is used in the fastener industry produces economies in making standard fasteners and specials . . .

How To Get Fasteners Quickly . . . if equipment is designed in the light of what is available, much grief can be avoided.

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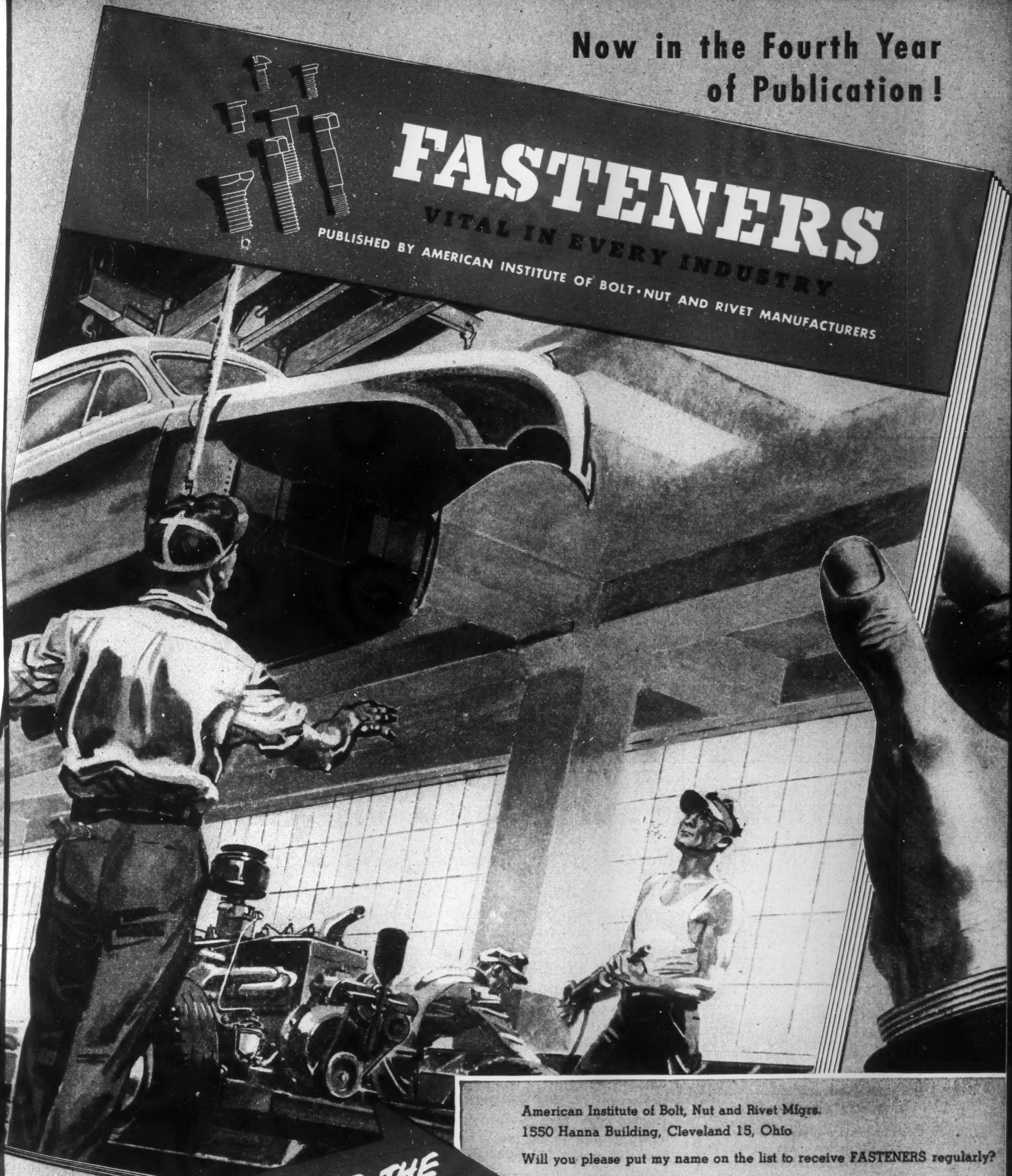
1550 HANNA BUILDING ◆ CLEVELAND 15, OHIO

Now in the Fourth Year of Publication!


FASTENERS
VITAL IN EVERY INDUSTRY
PUBLISHED BY AMERICAN INSTITUTE OF BOLT·NUT AND RIVET MANUFACTURERS
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1550 Hanna Building, Cleveland 15, Ohio

Will you please put my name on the list to receive FASTENERS regularly?

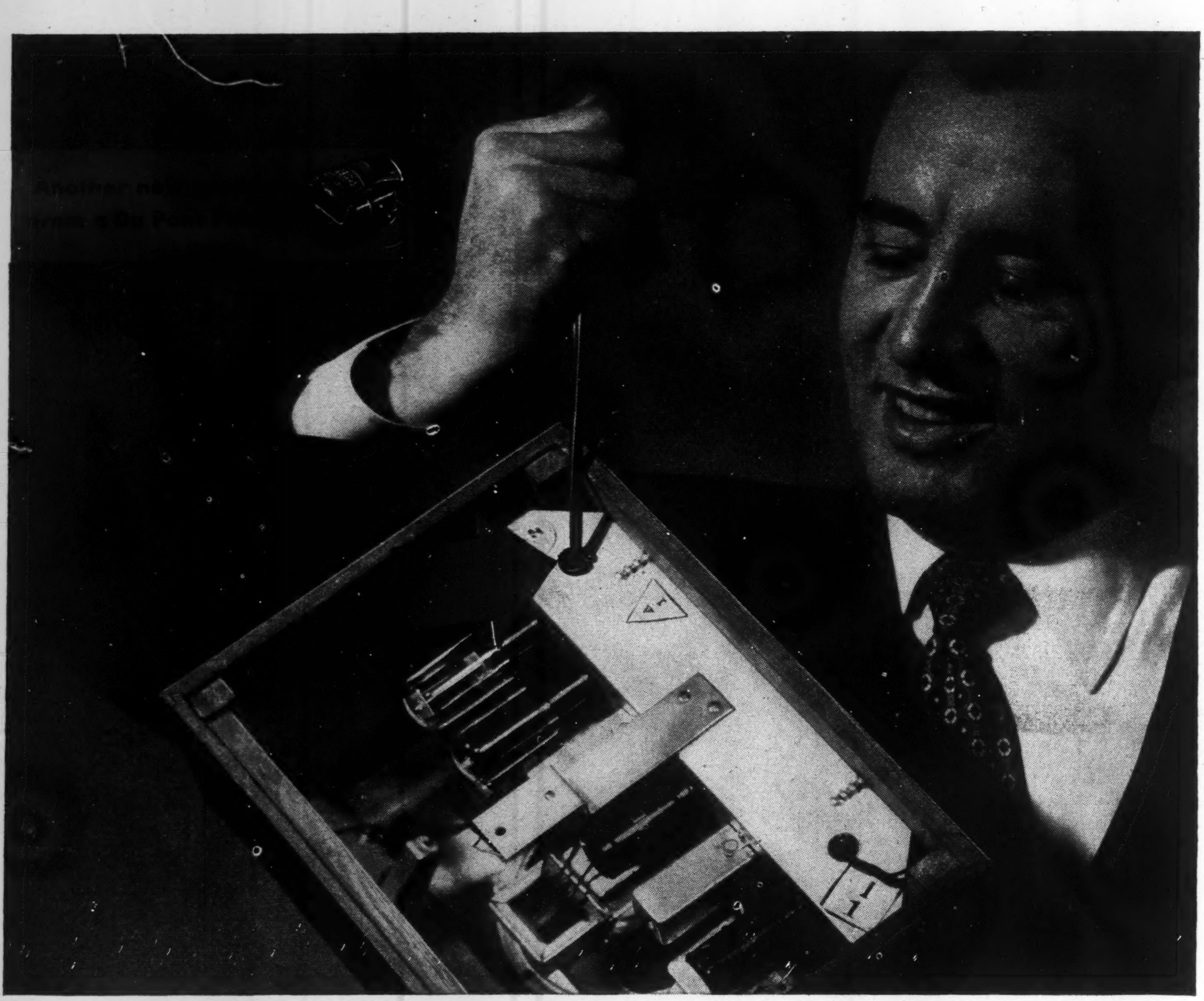
Name.. Title..............

Company..

Address..

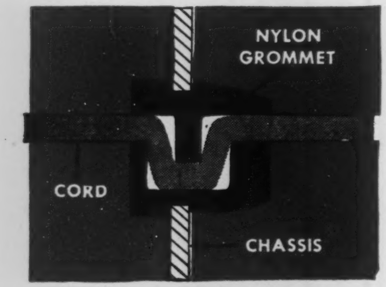
MD

If your name is not on the list— and you want FASTENERS....



NYLON GROMMET WITH A VISE-LIKE GRIP

New safety for appliances . . . molded from a Du Pont plastic



HOW NEW GROMMET WORKS

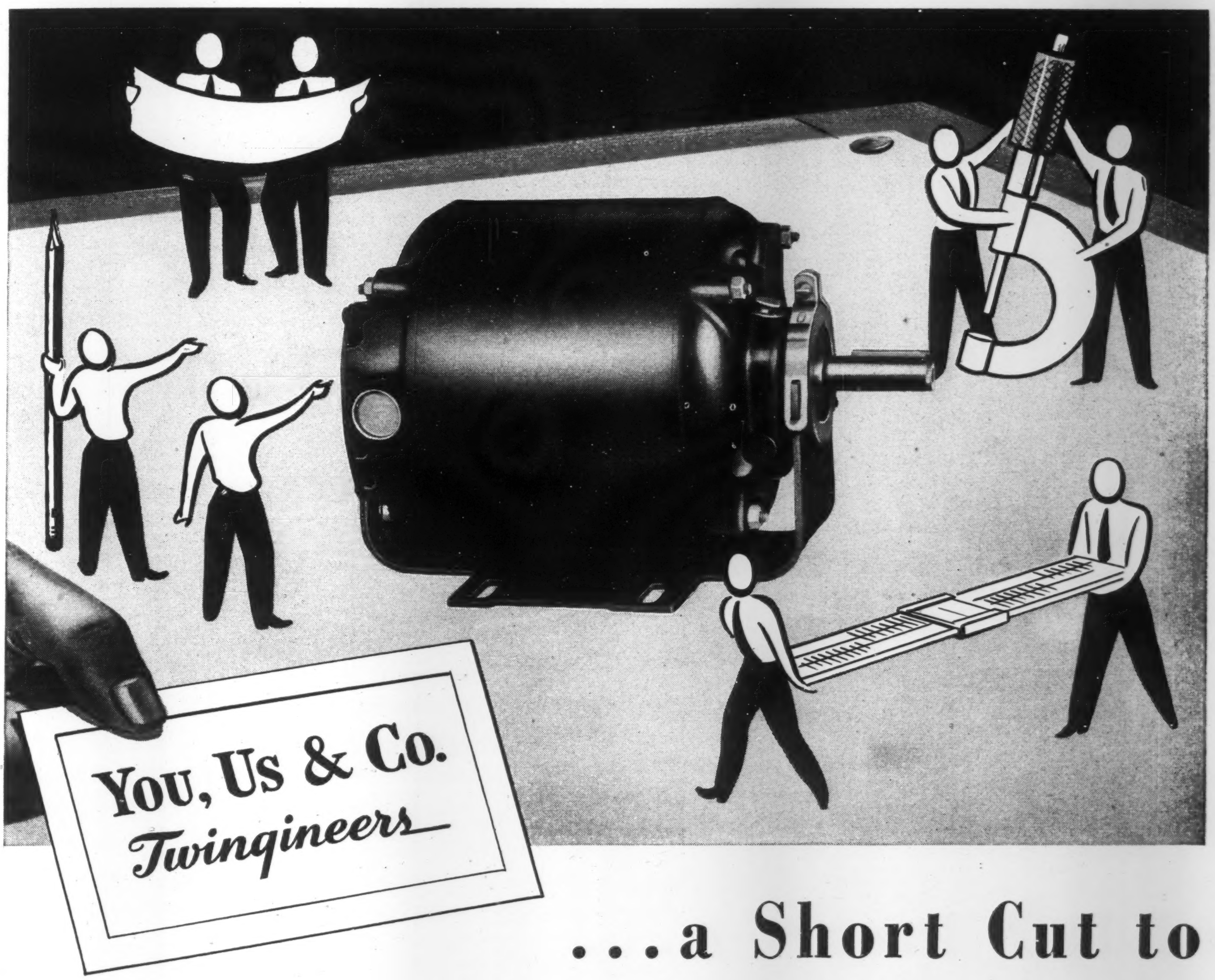
Grommet is two-piece assembly. Wire is placed across base piece. Top section is squeezed into assembly with pliers, locking wire in a safe hairpin turn. Grommet is then snapped into hole in appliance chassis. (Nylon grommet molded by Mack Molding Co., Inc., Wayne, N.J., for Heyman Manufacturing Co., Kenilworth, New Jersey.)

WELCOME NEWS for appliance manufacturers, underwriters and consumers is a new strain-relief grommet (or bushing) molded from Du Pont nylon.

Anchored into the chassis of the appliance, this mighty little nylon grommet keeps a tight, safe grip on lead-in wire. It absorbs the stresses of tugs and twists . . . protects connections against stripping, short circuits and moisture . . . adds a safety feature and a sales boost too. Nylon outpointed all other grommet materials tested by the manufacturer. Under heat test, for example, the nylon grommet withstands temperatures up to 400°F. It is economical to install . . . and it lasts the life of the equipment.

Want to improve an old product . . . design a new one? Look to nylon . . . and other Du Pont plastics . . . for a lift to success and more sales. Write for literature. E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Room 394, Arlington, New Jersey.

DU PONT
REG. U. S. PAT. OFF.
Plastics
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY



...a Short Cut to Lower Cost and Better Products

Two heads are better than one in designing motor-driven appliances and equipment to out-perform and outsell competitive products.

That's why you'll be time and money ahead when "You, Us and Co."—*your* Engineers and *Emerson-Electric* Engineers—collaborate in "blue-printing" your improved or future new equipment.

Your own *plus* Emerson-Electric's 57 years of engineering experience helps you eliminate costly engineering back-tracking, provides possible manufacturing short cuts, helps you market your new product with a competitive advantage, necessary for profitable merchandising.

At present, Emerson-Electric is booked solid on motor orders. But, our Engineering Staff has never been longer on down-to-earth ideas—and never more willing to share them in suggesting and designing money-saving Emerson-Electric motor drives for your appliances or equipment. Your inquiry is invited.

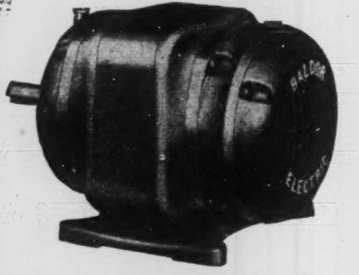
EMERSON-ELECTRIC MOTORS
1/20 to 5 H.P. A.C. & D.C.

THE EMERSON ELECTRIC MANUFACTURING CO., ST. LOUIS 21, MO.
***Branches:* New York • Chicago • Cincinnati • Detroit • Los Angeles • Davenport**

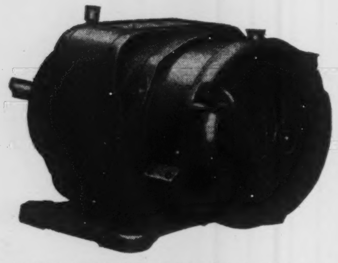
25

EMERSON ELECTRIC
MOTORS · FANS — APPLIANCES

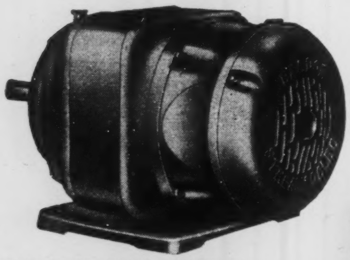
These BALDOR Streamcooled Motors *can't inhale* Dust, Dirt or Lint



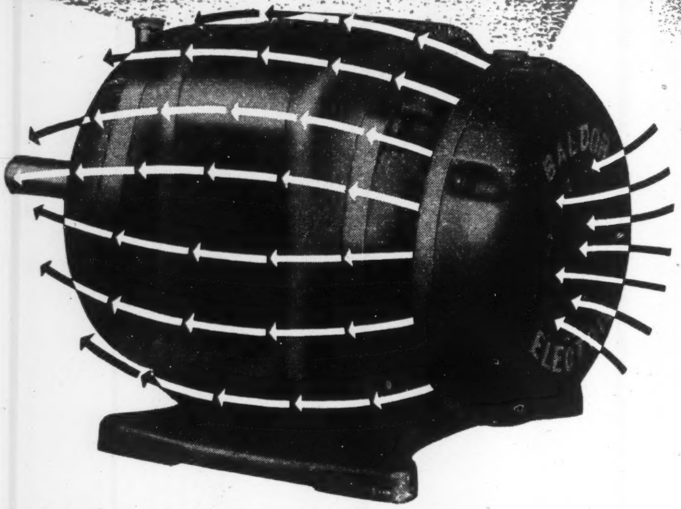
BALDOR STREAMCOOLED Polyphase Motor, 1 to 20 HP.



BALDOR STREAMCOOLED Direct Current Motor, 1 to 5 HP.



BALDOR STREAMCOOLED Single Phase Motor, ¾ to 7½ HP.



BALDOR STREAMCOOLED MOTORS ***are totally enclosed,*** **yet are constantly and efficiently cooled by a guarded outer-mounted fan forcing air over the entire exterior of the motor frame . . . as indicated by arrows in the above picture. This additional protection is an outstanding feature of all Baldor motors.**

Dust, dirt, lint, etc., cannot reach the inner mechanism of the motor to CLOG UP and reduce the operating efficiency of the motor. These motors, therefore, require LESS FREQUENT CLEANING . . . LESS SERVICING.

Baldor

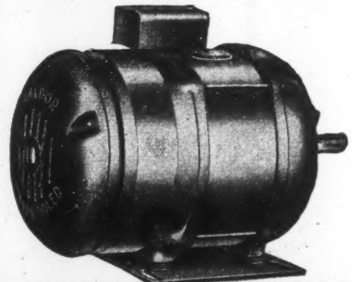
BETTER MOTORS

For More Than a Quarter of a Century

BALDOR STREAMCOOLED Face-mounted Vertical Motor, Single Phase, 3 Phase, and Direct Current.

BALDOR STREAMCOOLED Face-mounted Motor, Single Phase, 3 Phase, and Direct Current.

BALDOR STREAMCOOLED Round Frame Motor, ⅓ to ¾ HP., Single Phase, 3 Phase, and Direct Current.



GENERAL OFFICES AND FACTORY, ST. LOUIS 10, MO.

Speaking of HEAT EXCHANGERS You'll find ROSS first in so many uses

Why?

It's well known that over 81% of the Diesel engine builders use Ross lube oil and jacket water coolers . . . that an overwhelming percentage of hydraulic press builders use Ross oil coolers . . . that the U. S. Navy is a mammoth consumer of Ross oil and water coolers and heaters . . . and on and on it goes in the chemical, food, petroleum, machinery, paper mill and other fields!

But, why? First of all, industries like standardized lines. They mean mass production—faster, more economical output. Ross is a leader in standardization of coolers, heaters, heat exchangers, condensers. Secondly, industries like the possibility of tailor-made features in Ross standard equipment—individually assembling STANDARD parts to meet individual requirements. They mean meeting your operating conditions and performance needs *exactly* without paying a premium for specially engineered units.

Just as soon as your next heat exchange problem comes up, call in a Ross engineer. He'll show you how Ross standardized lines can be tailored to your needs.

In the meantime, send a request on your company letterhead for whatever Ross bulletins you'd like for your files.

ROSS HEATER & MFG. CO., INC.
Division of American Radiator & Standard Sanitary corporation
1429 WEST AVE. BUFFALO 13, N. Y.

Ross equipment is manufactured and sold in Canada
by Horton Steel Works, Ltd., Fort Erie, Ontario

ROSS

ROSS
Coolers

BULLETIN 5322
Type "CP"—larger oil and water coolers.

ROSS
TYPE "BCF" Lube Oil & Jacket Water COOLERS
ROSS HEATER & MFG. COMPANY, INC.

BULLETIN 4922
Type "BCF"—smaller oil and water coolers.

ROSS
Instantaneous HEATERS

BULLETIN 3623-A
Type "IS"— instantaneous heaters for water, oils, chemicals.

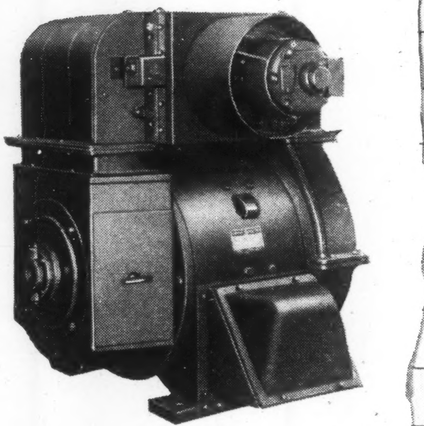
ROSS OIL HEATERS
ROSS HEATER & MFG. COMPANY, INC.

BULLETIN 3624-A
Type "O"—oil preheaters
Type "TS"—tank suction heaters for heavy fluids.

ROSS TYPE "BCP" LUBE OIL & JACKET WATER COOLERS
ROSS

BULLETIN 5222
Type "BCP"—oil and water coolers, marine design.

DESIGNER'S Digest



IT'S NEW!

VERSATILE D-C POWER for DIRTY JOBS!

G-E announces new totally enclosed, unit-cooled d-c motor...10-200 hp!

G-E UNIT-COOLED D-C MOTOR DATA

RATINGS
10-75 hp adjustable speed.
50-200 hp at 1150 rpm.

TEMPERATURE RISE
55 degrees C (Class A insulation, 40 degrees C ambient at 3000 feet altitude or less. Class B insulation is also available.)

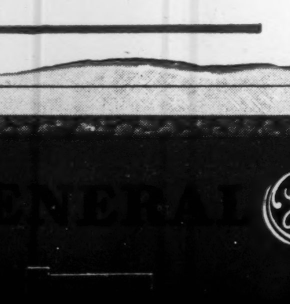
WINDINGS
Shunt, stabilized-shunt, and compound types for different starting loads.

CONSTANT SPEED
Limited to 25 to 100% speed increase by field control.

ADJUSTABLE SPEED
Speed increases of 300 to 600% of basic speed.

HOW A UNIT-COOLED MOTOR IS VENTILATED

The unit cooler, mounted on top of the motor, is a surface cooler of the "air-to-air" type. Clean warm air (blue arrows) is pulled from the totally enclosed motor by a shaft-driven fan and forced through the cooler. Cool outside air (black arrows) is drawn into the cooler by a separate motor-driven blower to absorb heat from the internal air stream. For a more detailed description, check Bulletin GEA-4469.



Once again G.E. leads the way with a tough yet versatile d-c motor for the dirtiest jobs in industry. This d-c unit-cooled motor withstands atmospheric conditions intolerable to an open or partially-enclosed motor. Dirt, dust, metal particles, and oil are *sealed out* because this motor contains its own totally enclosed ventilating system. Without duct work, piping or air-filters, your important drive motors run smoothly and reliably. Besides, you get all the benefits of versatile d-c motor power. Note these big advantages:

MACHINES STAY ON THE JOB LONGER

No air-borne material can get to the operating parts of this G-E unit-cooled motor. Windings, brushes, and brush riggings stay clean. Motor failures are reduced — machine output increased.

MOTOR PERFORMANCE IS MORE EFFICIENT

The high thermal efficiency of the unit-cooler makes possible for the first time a totally enclosed, direct-current machine in larger sizes with the high performance standards of the open motor. Power consumption is less than that of a conventional fan-cooled motor, particularly where a wide speed range is employed.

MAINTENANCE COSTS STAY DOWN

Large end-shield openings, fitted with easily removable gasketed covers, permit ready access to commutator, brushes, and brush rigging. Bearing-lubricant fittings are also easy to reach.

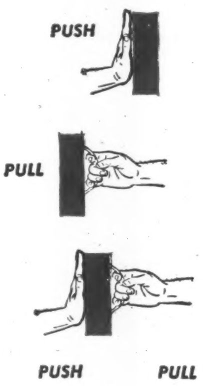
INSTALLATION COSTS ARE LESS

G-E unit-cooled motors have the same mounting dimensions as G-E open (dripproof) and splashproof motors in the same ratings. Being a self-contained unit, auxiliary ventilating fixtures are eliminated.

GENERAL ELECTRIC

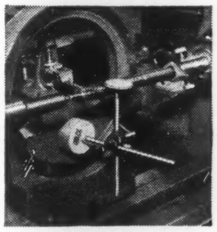
TIMELY HIGHLIGHTS ON GE PRODUCTS

0.9 to 97 lbs.
of push and pull!



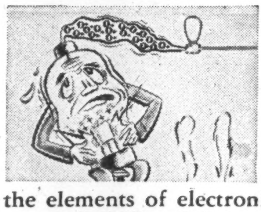
Have you a machine operation where a pushing or pulling motion is required? G-E solenoids can do either or a combination of both. These self-contained, sturdily-built units give long reliable service. Maximum voltage for all types is 600; 60 to 25 cycles and d-c. Stroke lengths from ¾ to 3 inches are available. Push or pull forces range between 0.9 and 97 pounds continuous duty. There are 10 a-c and 7 d-c sizes available to cover this range. G-E solenoids designed for a-c can be used on d-c applications by adding cutout switches. For further information check GEA-2080 on coupon.

STAYS "PUT"...
without Clamps or Screws!



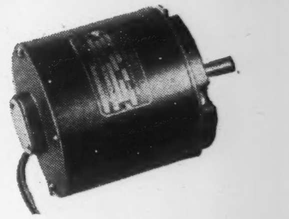
How can you use this G-E magnetic stand? You place the base on a steel or iron surface (table top, machine tool surface, or wall) and it stays "put" without clamps or screws. You can then attach test fixtures, dial indicators, and other instruments to the rod. Normal vibration will not cause it to "creep" out of alignment. To make minute adjustments in the location of the stand, you merely push its base or tap it slightly with a mallet. Stand is 8 inches high; base, 2½ inches in diameter. Check Bulletin GEA-4332 on coupon.

MORE "KNOW" MEANS BETTER "DO"!



To help train new technical personnel, and make supervisory and production men's jobs mean more, G.E. offers this 12 part talking slide film, prepared to teach even non-technical personnel the elements of electronics. This easy-to-understand course in industrial electronics is "packaged" so that sessions can be successfully conducted by "home-talent" instructors. You furnish the instructor, meeting place, projector and record player. Everything else is in the kit. Complete with 12 slide films and records, 300 review books, instructor's manual and carrying case, price of the kit is $100. Call your local G-E office, or order direct from *Apparatus Dept., Sect. 668-53, General Electric Company, Schenectady 5, N. Y.*

TO MEASURE LOW RPM
here's a new a-c "tach"!

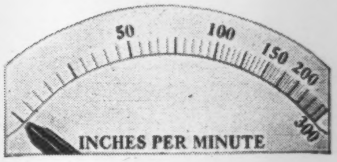


G.E. has developed a small, self-excited a-c tachometer generator, Type SMY-54, designed specifically for low speed operation. It has a speed range of 10 to 1000 rpm.

In this new a-c tachometer, there are no brushes and, consequently, no voltage inconsistencies . . . even at speeds as low as 10 rpm. It is not necessary to use large contact rolls to obtain speed amplification. Moreover, the light weight and small size of the contact roll which can be used with this tachometer enhance its usefulness in applications where space is limited and where contact roll pressure must be kept to a minimum (in extruding metal alloys and plastics, for example).

The G-E Type SMY-54 tachometer is wired to a voltmeter which can be calibrated either in inches per minute or in revolutions per minute. The instrument may be mounted apart from the generator to be within the normal range of vision of the machine operator. A recording instrument may also be added to provide a graphic record of machine speed. For complete details, check Bulletin GEA-4324 on the coupon.

G.E. can supply this special scale for use with the Type SMY-54 tachometer. It makes possible very accurate measurements at low speeds, without sacrifice of wide speed range.



TO GENERAL ELECTRIC COMPANY
Section E 668-53, Schenectady 5, N. Y.

Please send me the following bulletin(s):

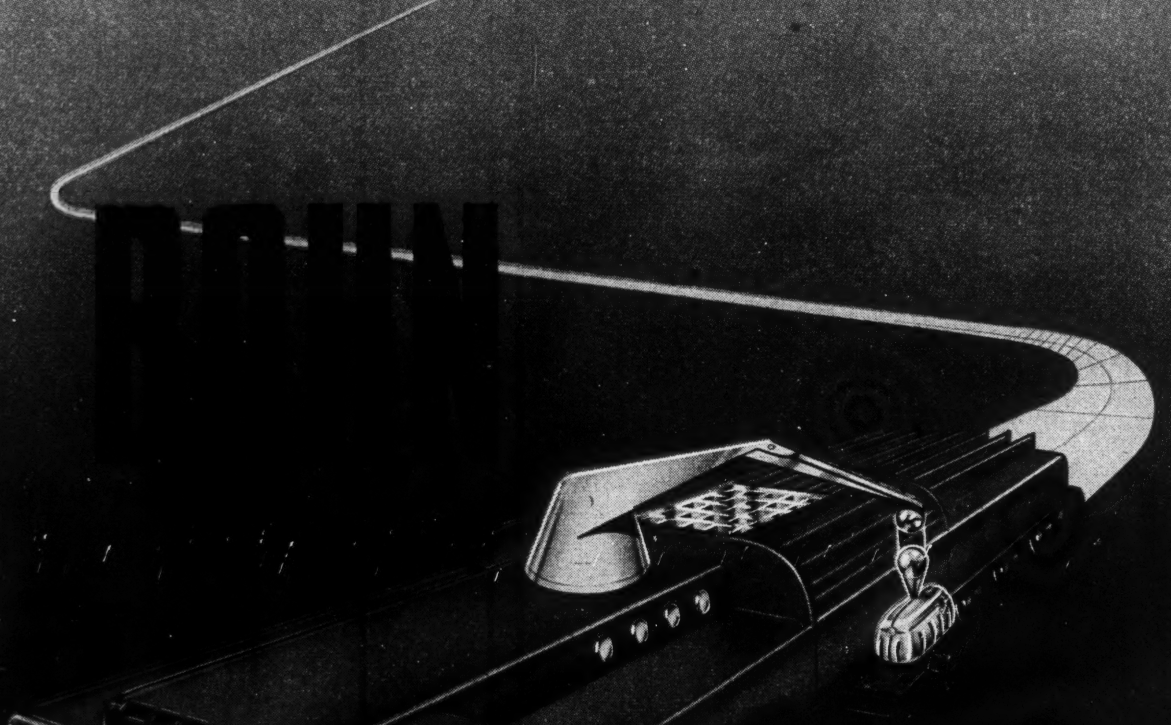
GEA-4469 — Unit-Cooled Motors . . . . ______
GEA-2080 — Solenoids . . . . ______
GEA-4332 — Magnetic Stands . . . . ______
GEA-4324 — Tachometers . . . . ______

Name______
Company______
Street______ State______
City______

CONSULT YOUR SWEET'S! You'll find "everything electric" for machinery manufacturers in the General Electric section.

More and more are advanced light alloys by Bohn being used in an ever-expanding variety of new products.

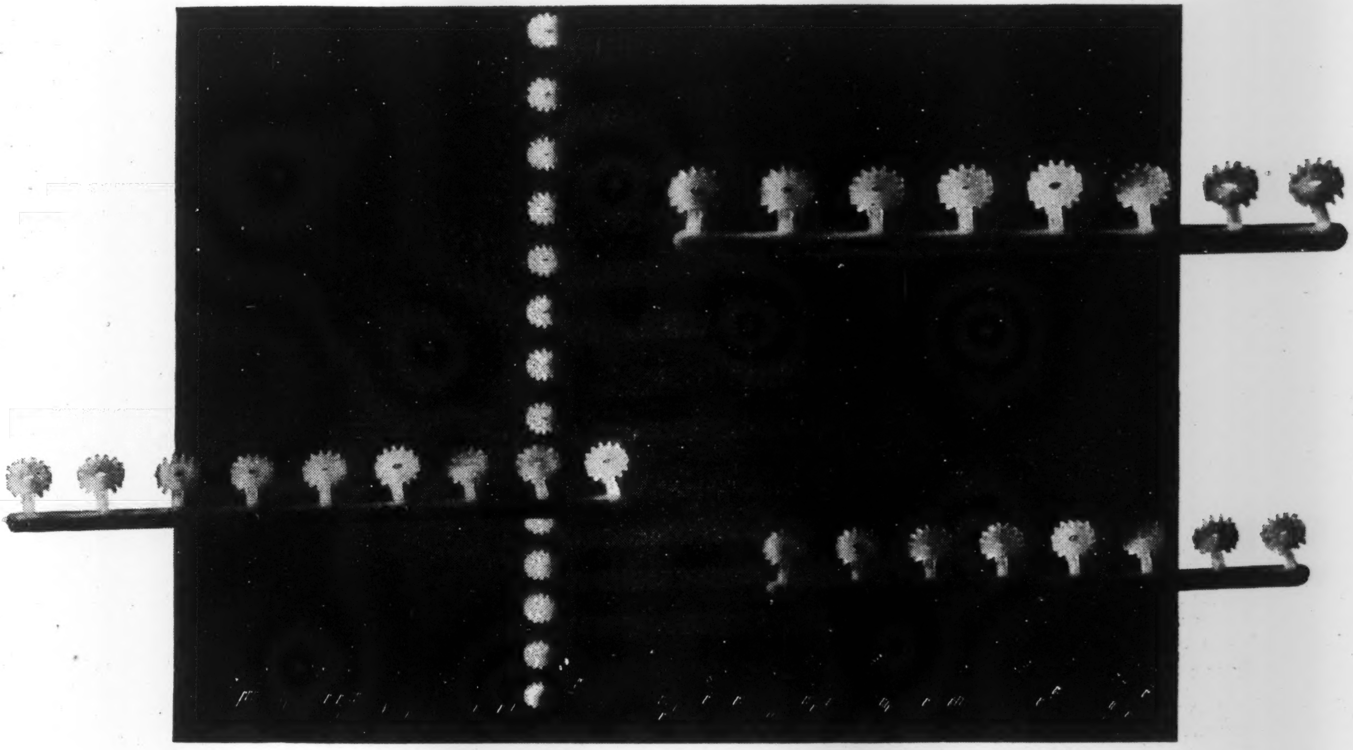
BOHN ALUMINUM & BRASS CORPORATION — GENERAL OFFICES, LAFAYETTE BUILDING, DETROIT 26, MICHIGAN
Designers and Fabricators—ALUMINUM • MAGNESIUM • BRASS • AIRCRAFT-TYPE BEARINGS



A RADICAL DEPARTURE IN
ROAD BUILDING EQUIPMENT

GEARS: *Precision molded*

Semenoick + Stoller



Silent and tough, NYLON gears give better performance and save thousands of dollars in certain applications requiring large quantities. When the Aerequipt Corporation of Mt. Vernon, N. Y. changed from Brass to Nylon for the Spur gears shown above, they gave the production problem to Atlantic of New York which molded them within maximum tolerances of .002".

This is a typical example of Atlantic's skill in precision molding.

A
ATLANTIC
OF NEW YORK

ATLANTIC PLASTICS, INC.

132-27 FORTIETH ROAD, FLUSHING, N. Y. • "Here dwells ingenuity"

Topics

CARBIDE PARTS with inserts of machinable material for attachment by drilling, tapping, etc., makes application easy for crank guides, cams, machine ways, shoes, and wear plates. Method, developed by Carboloy Co. Inc., permits the use of blind holes where through holes would be objectionable or where brazing is undesirable.

INTERMITTENT STARTING of high-speed motors is responsible for 50 per cent of the wear on ball bearings during their normal life. Inertia of the balls is such that slippage is excessive during the time they accelerate to rolling speed.

TIRE-PRESSURE METER for vehicles gives audible and visual indication when any tire is soft. Buzzer and a pilot light for each tire are mounted on the dash to signal the driver. Pressure-actuated buttons inside the tire rim are in contact with the inner tube and are connected to the dash panel through brass ring mounted on brake drum and carbon brushes mounted on axle.

MARINE RADAR, scanning the horizon 40 times a second, transmits and receives pulses at 2/5 of a millionth-second or about ten times faster than war-time radar. Produced by A. C. Cossor Ltd. of London and distributed by Sylvania Electric Products Inc., the equipment produces good definition at short ranges up to 15 miles.

SILICONE-INSULATED motors will last about 900 times as long as Class B motors, according to accelerated life tests by Dow Corning Corp. The test motors were operated at temperatures up to 590 F. Also, in tests, DC 44 silicone grease adequately lubricated a bearing for 495 hours at 350 F.

DAMPING SCREENS of fine mesh have made it possible to reduce air turbulence in wind tunnels, simulating conditions of high speed in still air. The screen is placed across the section upstream of the entrance cone to give smoothness and uniformity to the air flow. The small-scale turbulence introduced by the screen decays much faster than the larger surges of turbulence in the new method developed by aerodynamic experts at the National Bureau of Standards.

HEAT RESISTANT PAINT known as Triple-A, developed by the Quigley Co., withstands temperatures up to 2500 F on some alloys. It will adhere on steel at temperatures of 1400 F under conditions of rapid cooling and heating, and is resistant to water, gasoline, oil, and benzol.

GLASS is being sprayed on wire and narrow strip to eliminate the need for cleaning the metal with acid. The glass is applied near the finish of the rod-rolling operation and cracks off at about 400 F. pulling away the surface oxides with it.

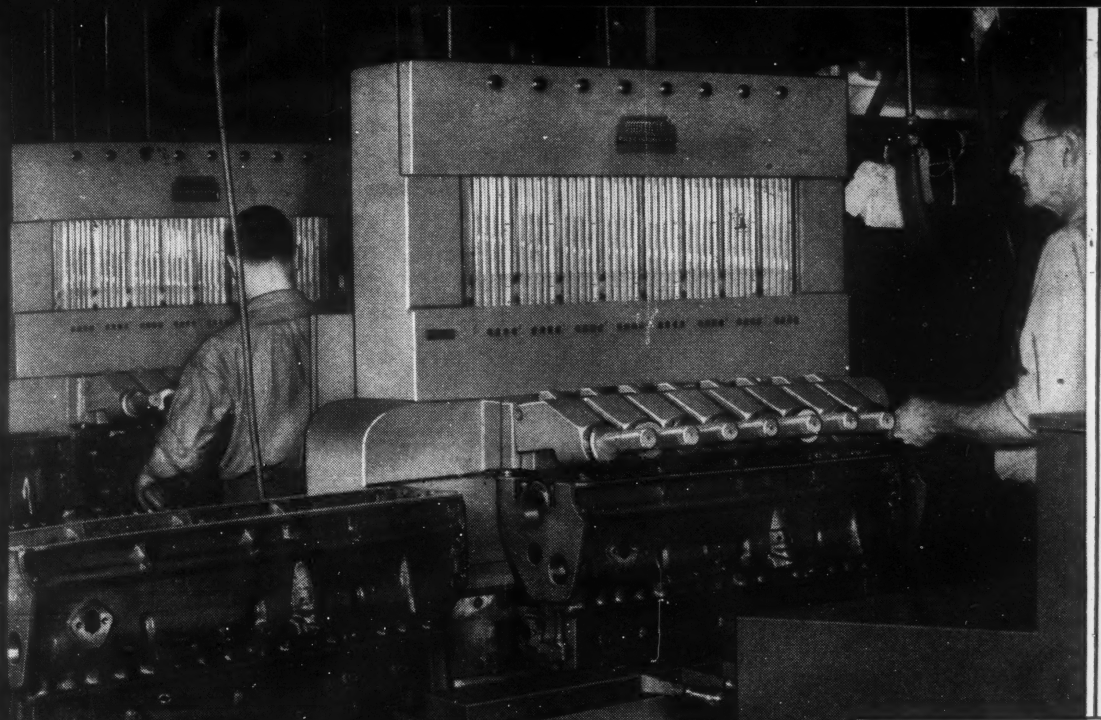
CROSS-ROADS in the synthetic-rubber program has been reached. By a little timely effort it is possible to consolidate wartime gains and obtain for this country security against future war shortages and against foreign economic invasion. A few months of apathy and delay, according to R. P. Dinsmore, may mean that we have sacrificed nearly all of our present advantages.

STAINLESS-CLAD steel, for parts usually chromium plated, will not chip, peel or flake. Clad sheets supplied by Jessop Steel Co. are made with 10 to 20 per cent stainless cladding on mild steel.

IN SUBZERO TEMPERATURES, precision lenses are being removed from pitch in a fraction of the time formerly required. Chilling shrinks the pitch, making lens easily lifted. Former method of melting often damaged the glass and required a subsequent cleaning operation.

ELECTROMAGNET developing a 4000-pound pull, a force strong enough to make possible new studies in magnetism, has been developed by Westinghouse. Having 6000 turns of square copper wire this 28,000-watt magnet requires 17 gallons of oil per minute for cooling.

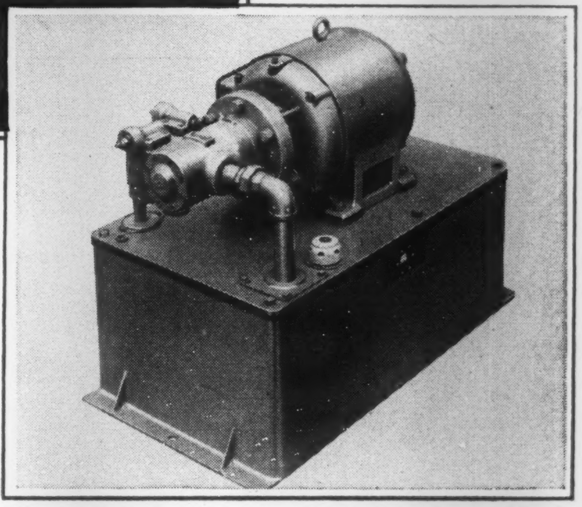
City Libr



At Left: Sheffield Precisionaire Gaging Machine simultaneously checking 32 points of inspection.

This is one of a series of applications pointing out the many advantages of Vickers Hydraulic Controls.

Below: Vickers Hydraulic Power Unit installed in base of Sheffield Precisionaire Gaging Machine.



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One push button puts motions No. 1, 2 and 3 (above) into automatic operation; another push button actuates motion No. 4 while a third actuates motion No. 5. To get them all into limited space with proper sequential timing by any other means would have been a difficult problem for the designer. But Vickers Hydraulic Equipment simplified the job. Hydraulic pressure is supplied by a Vickers Power Unit which consists of motor, tank, pump and relief valve all in one compact assembly ready to connect to the hydraulic circuit.

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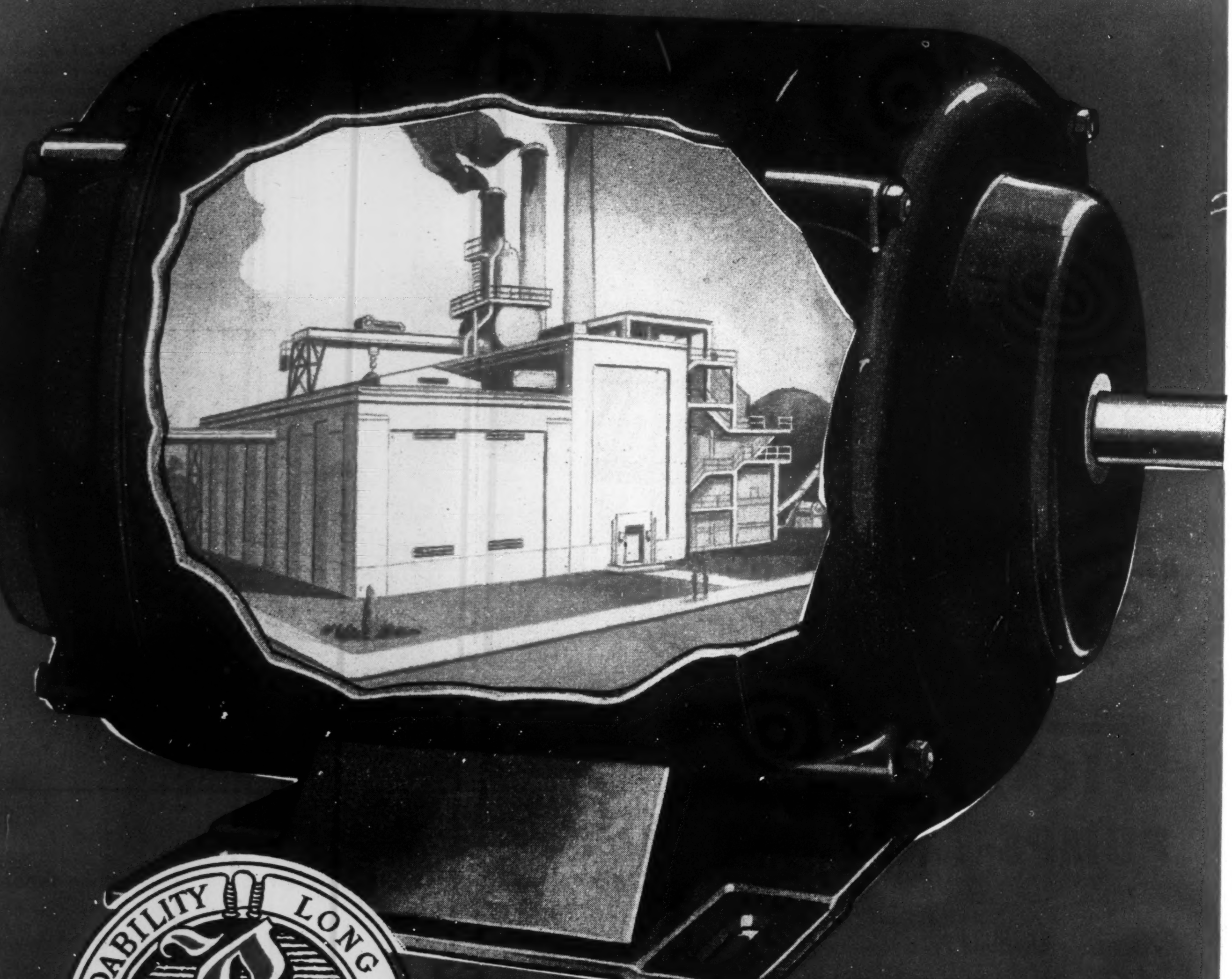

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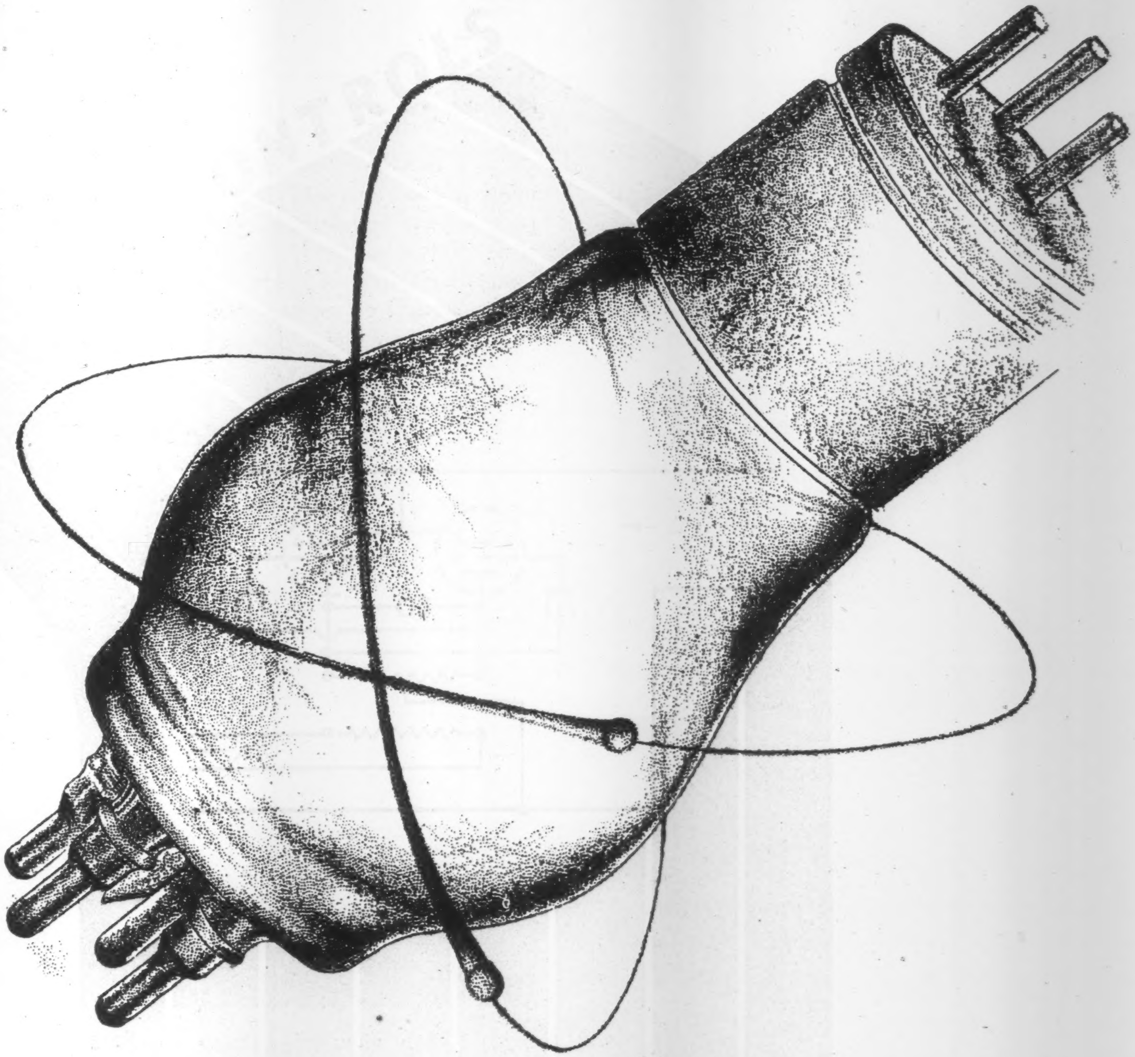


Electronic Control

. . . of mechanisms for automatic circular knitter has definite advantages in flexibility, safety, compactness, and cleanliness

By H. W. Anderson
President
Fidelity Machine Co. Inc.
Philadelphia

USE of nylon now permits the manufacture of fine seamless hosiery on small, precision, high-speed circular knitting machines, fully and permanently fashioned to form by preboarding. Previously produced from fragile silk and rayon, full-fashioned stockings could only be manufactured in a flat blank, the finished product being completed by a seam running from toe to top. Machines for knitting full-fashioned hosiery in this manner are large, ranging from twenty-four to thirty sections and weighing as much as fifteen tons.

Possibilities of the new field offered a challenge to textile engineers, resulting

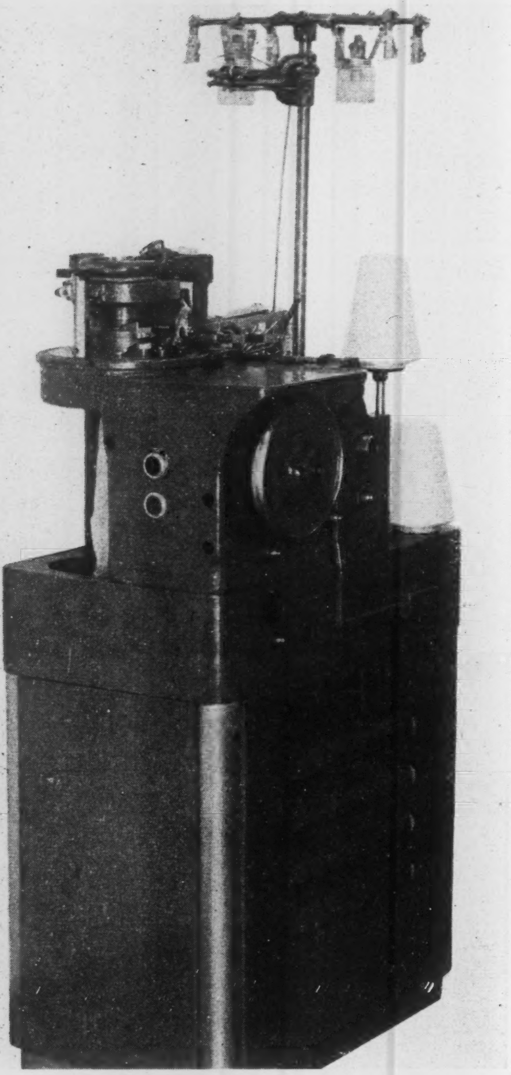
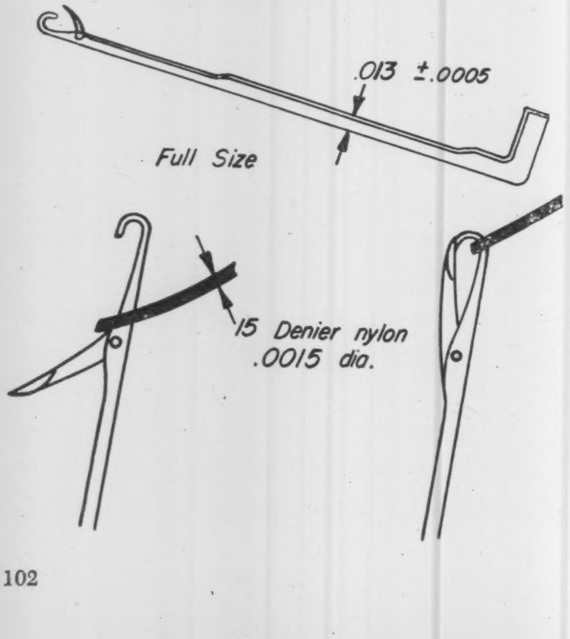


Fig. 1—Above—Electronically controlled no-seam hosiery knitting machine with all elements of drive enclosed in housing below knitting head

Fig. 2—Below—One of two fine-gage latch needles used on the circular knitting machine showing enlarged views of the latch



in the development of electronic control for high-speed circular knitting machines. It was only logical to think of the future as one in which unlimited speed variations would be required from knitting machines using many new types of synthetic yarns having many varied characteristics. Increased yarn tensile strength will permit increased knitting speed and finer diameters of filaments will involve improved stop-motion controls, all features of which lend themselves to overall electronic control. In addition, electronic control of motor speed and direction of rotation as well as stop motions will provide ready adjustment to innumerable variations that may well develop in the future without affecting the basic machine design.

With the application of the electronic motor control, the practical approach to design involved the enclosure of control apparatus within a modernly conceived cabinet which would serve the double function of a storage unit and substantial foundation for the mechanisms producing the stocking, *Fig.* 1. To fully appreciate the various control functions necessary for successful operation in circular knitting of hosiery, the various mechanical operations and steps in processing will be outlined briefly.

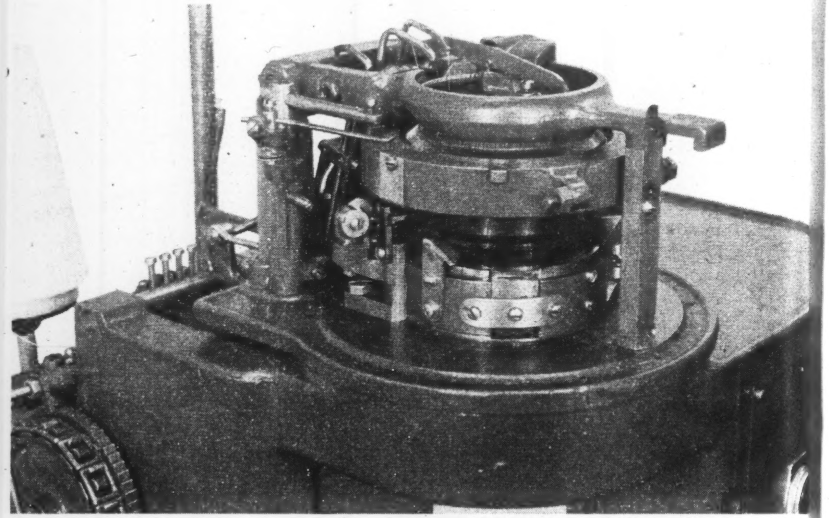


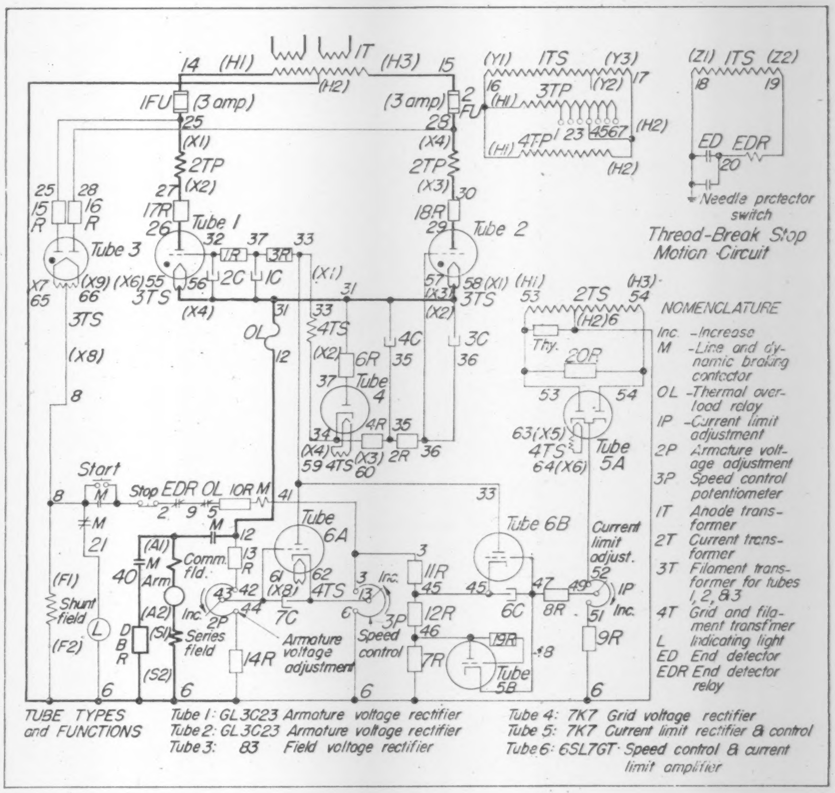
Fig. 3—Top view of knitting machine showing the 400-needle knitting mechanisms and a portion of the ratchet wheels and cams

Knitting starts at the top, or welt, of the stocking and continues through, finishing at the toe when the completed article separates from the needles and drops into a receptacle provided in the machine. Each completed stocking after inspection requires only the closing of the toe, an operation known as looping which is performed on a separate machine. Following this operation the stocking is placed on a leg-and-foot shaped stainless-steel form, is subjected to steam atmosphere where, with pressure and high temperature, there emerges a permanently form-fitting stocking.

In the circular knitting head there are 400 accurately machined latch needles, *Fig.* 2, arranged in a circle of 3.750 inch diameter, and these needles slide in individual slots in a vertical direction. The butts (end of needle opposite hook) run in a cam path which changes during the course of production of the stocking to perform the necessary stitch variations required, *Fig.* 3. When all 400 needles have made a complete 360-degree travel, the machine has turned one revolution.

Since several types of yarn are involved at different points of

Fig. 4—Right—Electrical circuit diagram for the knitting machine which includes both the electronic and thread-break stop motion circuits


Tube 1
Tube 2
Tube 3
Tube 4
Tube 5A
Tube 5B
Tube 6A
Tube 6B
Start
Stop
Comm. fld.
Arm
Shunt field
Series field
Armature voltage adjustment
Speed control
Current limit adjust.
Needle protector switch
Thread-Break Stop Motion Circuit
NOMENCLATURE
Inc. -Increase
M -Line and dynamic braking contactor
OL -Thermal overload relay
IP -Current limit adjustment
2P Armature voltage adjustment
3P Speed control potentiometer
IT Anode transformer
2T Current transformer
3T Filament transformer for tubes 1, 2, & 3
4T Grid and filament transf'mer
L Indicating light
ED End detector
EDR End detector relay
TUBE TYPES and FUNCTIONS
Tube 1: GL3C23 Armature voltage rectifier
Tube 2: GL3C23 Armature voltage rectifier
Tube 3: 83 Field voltage rectifier
Tube 4: 7K7 Grid voltage rectifier
Tube 5: 7K7 Current limit rectifier & control
Tube 6: 6SL7GT Speed control & current limit amplifier

each stocking construction, these different yarns are introduced into action and withdrawn at varying speeds from cycle to cycle. To form the heel, gears are shifted under the control of cams to cause the needles to alternately travel in forward and reverse directions to form the angle in this part of the foot. The reversals then cease and knitting progresses through the foot to the toe where reciprocation again occurs. The "pattern" link chain which is clearly visible in *Fig.* 3 controls the number of courses of each portion of the stocking through the racking and movement of a master fashioning drum and cam. Desired sequence control is attained through the use of pattern links of various heights and shapes. The pattern chain is slow moving and, because construction specification changes occur continually in hosiery manufacture, has been left exposed purposely to permit hosiery fixers ready, unhampered access.

A mechanism is provided for automatically ejecting the finished article, rethreading the machine and restarting, all without the need of assistance from an operator. All automatic mechanical functions are initiated from a master control cam that also dictates the speed at which the driving motor operates at each point in the knitting cycle.

Main features which were found desirable and in certain cases necessary for efficient design and operation of the knitter may be outlined as follows:

1. Motor rated ¼-hp at 1725 rpm with flat speed-torque curve for driving friction loads
2. Motor vertical and enclosed for protection
3. Drive capable of operation on 220, 440, or 550-volt systems, interchangeably, to eliminate problem of anticipating ultimate mill purchasers' requirements in this respect
4. Motor speed adjustable over a 7 to 1 range and means for making adjustment easily adaptable to simple cam control
5. Drive to permit furnishing a complete unit with each individual machine for maximum flexibility in arrangement and addition of units in the mill
6. Means limiting motor torque delivery in event of needle breakage and subsequent mechanical jam in the machine
7. Means of automatic acceleration to a preset speed; acceleration to be smooth to insure that yarn is handled gently
8. A stop-motion relay control to shut down drive in the event of yarn breakage; a source of low-voltage ac current for use in operating safely a yarn-feeler switch and relay-coil circuit whose contacts are exposed to the operator; a red signal light to indicate when the drive is shut down
9. All elements of the drive to have a thermal capacity sufficient to operate continuously in cramped quarters.

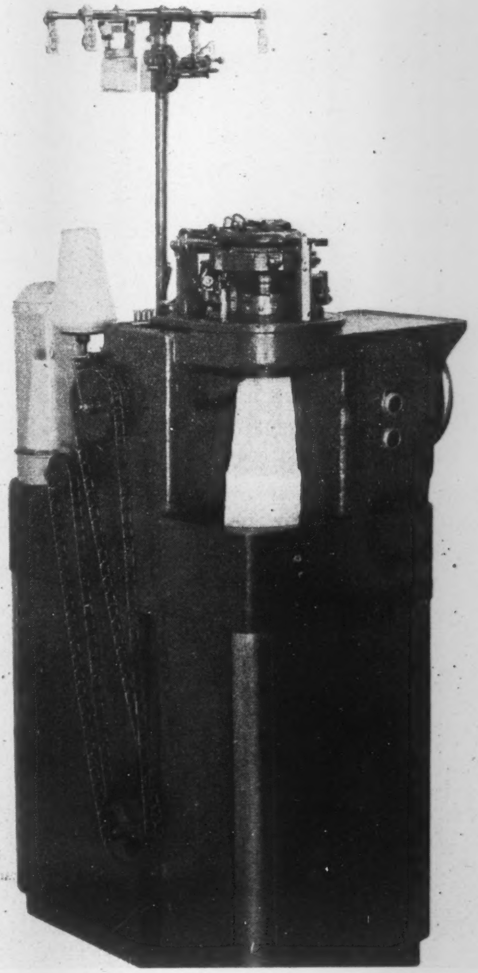


Fig. 5—Right—View of knitting machine from opposite side showing clean, unobstructed lines. Enclosure presented no heating problems

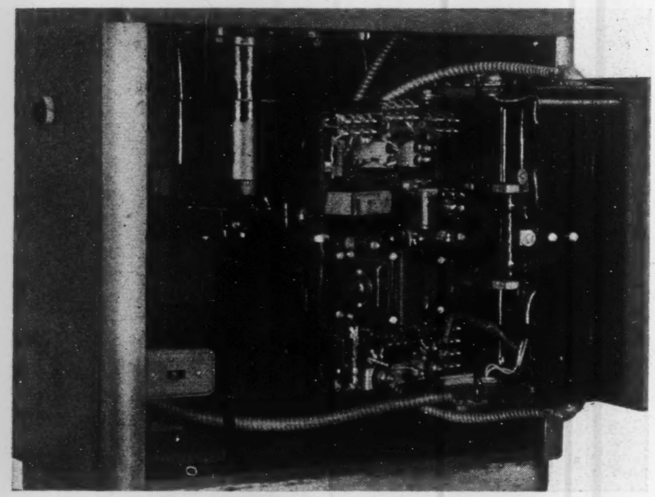
10. Motor and control panel so designed as to assure easy accessibility for the performance of maintenance functions; furthermore the design must facilitate installation and removal from the machine enclosure.

Conventional design of circular knitting machines has always involved the use of a tight and loose pulley belt drive arrangement powered from a line shaft with one motor for a group or line of machines. A pair of pulleys with a fork for shifting the driving belt to permit starting and stopping individual machines has been accepted practice. Usually line shafts and hangers have been located on the operating floor in a straight line behind the machines and it is unnecessary to comment upon the inconvenience of fast running belts when operators must of necessity function from all sides of the machine. Control mechanisms for the earlier belt-driven machines are relatively expensive and, for this reason primarily, incorporate only two speed levels within the stocking cycle. Conventional yarn-break stop motion consisted of yarn-feeler switches in series with the coil of a relay whose contacts are in the coil circuit of a belt-shifting solenoid. The only protection provided against development of ruinous torques in the event of needle jam has been the hope that the drive belt would slip sufficiently on its pulley to limit the torque delivered.

The electronic motor control includes an anode transformer with a 220, 440, and 550-volt primary permitting installation of this drive on any common industrial power system. A special 24-volt secondary tap provides a source of low-voltage power for use in the yarn-break stop-motion circuit. A 7 to 1 speed range is well within the capacity of the unit.

Speed adjustment is provided by a potentiometer which is cam operated. A potentiometer capable of one million operations was selected so that at two shifts a day with a five-day working week, the life expectancy will be upwards of twenty years. A small pinion mounted on the shaft of this device meshes with a rack and the rack in turn is positioned by cams in the machine control mechanism. Incorporated in the design of the potentiometer mounting is a means for presetting maximum and minimum speed limits. Since as many intermediate speed levels as may be desired to secure most economical hosiery production are available, this becomes possible without the addition of costly mechanical gear-shifting.

Fig. 6—Entire control box slid out on tracks and opened to show wiring, etc. Servicing is readily accomplished



Due to a variety of possibilities, a needle butt may break during operation and if this should occur without protection, the needles would jam in the cam slot and stall the motor. In order to protect the machine elements, it was evidently desirable that the drive be de-energized immediately, or that the motor torque be limited to a safe, low value. Since there was no readily available method for shutting down the drive, the latter approach has been employed. By setting the current limit value at 1.8 amperes, tests showed: (a) The drive motor satisfactorily breaks away its load, (b) acceleration is at a smooth, controlled rate, (c) required torque is available at all points in the duty cycle and, (d) the locked-rotor torque is sufficiently small to insure against damage to the mechanisms when a needle jam occurs.

Since all modern knitting machines must stop immediately when thread or filament breakage occurs, a relay with a 24-volt coil was mounted for operation in what is termed the thread-break stop-motion circuit mentioned previously. This circuit is shown in the complete electrical diagram of *Fig.* 4. Experiments with thread breakage proved that the inherent frictional load was such as to cause the machine to coast to a stop sufficiently fast without the aid of dynamic braking.

Enclosure Offered No Heating Problems

In the overall design as finally accepted, illustrated in *Figs.* 1 and 5, the electronic equipment and controls, motor and transformer are located within the machine housing. Since the complete drive and control was enclosed, numerous tests were made with respect to possible overheating. However, all heat-run data under actual service conditions proved that the drive would meet all requirements in reasonable working temperature ranges.

For convenience in checking and servicing all control elements, the control box is mounted on a base which fits and slides in grooved tracks on the inside wall of the machine cabinet as illustrated in *Fig.* 6. In order to inspect the panel it is necessary to remove only the detachable side of the knitting machine housing and slide the electronic control box to a position easily accessible from the aisle, *Fig.* 6. The spacing of the machines in mills has been recommended to be sufficient for permitting removal of electrical equipment when required. This spacing by coincidence proved to be the ideal working room for an operator around the knitting machine.

In conclusion it might be well to mention that relative to this particular machine it is believed that the electronic drive and control system made possible definite advantages in respect to flexibility, safety, compactness and cleanliness, and helped tremendously in attaining an outstanding advance in knitting machine design. Acknowledgement is gratefully accorded the cooperation of Messrs. R. J. Demartini and J. Towne of the General Electric Co., and Walter Larkin of the Fidelity Machine Co. Inc., whose efforts have made a contribution which it is believed will prove most important to the knitting industry.

Fractional-Horsepower Motors

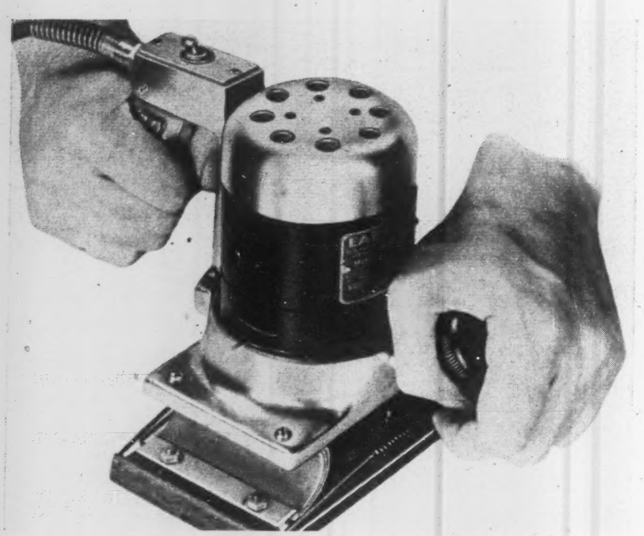
Matching their design features with application requirements

By W. M. Yogerst

Bodine Electric Co.
Chicago

BECAUSE many factors are involved in the application of fractional horsepower motors with respect to power supply, load characteristics, speed of the motor, and other considerations, an examination and analysis of all the factors would be beyond the limitations of a single article. This presentation, therefore, will attempt to help the machine designer recognize a few of the common problems which frequently present themselves.

Economics enters into the selection of fractional horsepower motors as it does any activity. Where the application involves a limited production in number of units,



Photo, courtesy Detroit Surfacing Machine Co.

Fig. 1—Portable sander employs series-wound motor to provide high speed and operation on ac or dc current

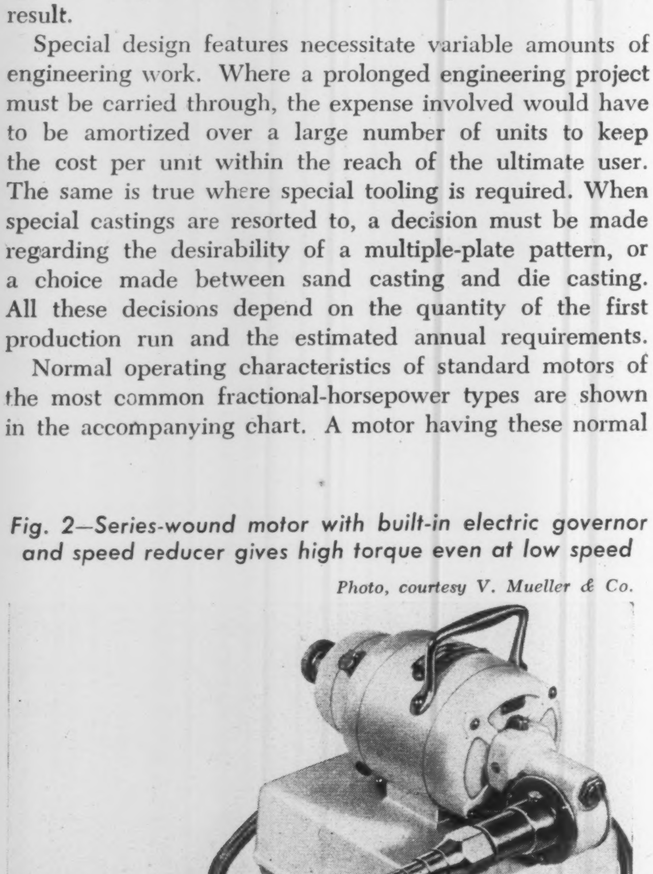
it is not generally found economically feasible to consider special design features. Standard motors and other components should be given first consideration and should be used except where their use would defeat the basic operating principles of the machine, or where only a special design of motor would accomplish the required result.

Special design features necessitate variable amounts of engineering work. Where a prolonged engineering project must be carried through, the expense involved would have to be amortized over a large number of units to keep the cost per unit within the reach of the ultimate user. The same is true where special tooling is required. When special castings are resorted to, a decision must be made regarding the desirability of a multiple-plate pattern, or a choice made between sand casting and die casting. All these decisions depend on the quantity of the first production run and the estimated annual requirements.

Normal operating characteristics of standard motors of the most common fractional-horsepower types are shown in the accompanying chart. A motor having these normal characteristics can usually be chosen to satisfy the requirements of most machines. Sometimes space limitations are such that a standard motor within the required dimensions falls short of the demands of the machine in one or more characteristics. For instance, a split-phase motor may drive the machine satisfactorily at the required speed, but it might lack sufficient starting torque. A special, high-resistance rotor can be designed to increase the starting torque, but at the expense of running torque and efficiency. As a result the speed at full running load will be reduced somewhat. In many applications the sacrifice in speed is not critical.

Fig. 2—Series-wound motor with built-in electric governor and speed reducer gives high torque even at low speed

Photo, courtesy V. Mueller & Co.



Operating Temperature Limits Rating

On the other hand, the starting torque might be increased by use of a stronger winding, which would draw more power from the line and result in a higher operating temperature. Any highly efficient standard motor operates at or near the maximum temperature considered safe for normal insulation life under continuous duty. A higher operating temperature can still permit normal insulation life, however, when the machine is sufficiently intermittent in its operation so that the motor never reaches its maximum temperature or does so only for short infrequent periods. A motor wound for higher than normal continuous operating temperature may be intermittently loaded in a cycle which will keep it within normal operating temperature. An application of such a motor is utilized in the duplicator machine shown in the head illustration.

The portable sander shown in *Fig.* 1 offers other interesting factors in successful motor application. A pinion cut directly on the motor shaft extension meshes with a gear attached to an eccentric movement, which in turn moves the sanding pad back and forth in a reciprocating motion. The vibration set up by this reciprocating motion calls for special sturdiness in internal motor construction. For example, a specially designed cooling fan was found necessary to prevent disintegration and consequential damage to the windings.

Lubrication and Ventilation Problems

Mechanical adaptation and lubrication are other important factors. Correct selection of pinion and gear hardening prolongs their life, but the lubricant selected must have good lubricating qualities, and at the same time, cling to the rotating parts at high speeds. It must also remain within its enclosure under the high pressure generated by the gears. A special-flanged end shield was designed for the motor to provide a tight fit for the gear housing as well as accurate pinion and gear alignment. A careful choice of ball bearing seal was required to help keep the lubricant from working into the motor where it would foul the commutator and cause trouble. In addition, a carefully designed member correctly located on the shaft acts as a grease auger and slinger to relieve pressure on the ball bearing seal.

Grit and motor ventilation afford another problem. A good blast of air must pass over the motor windings to

		Split Phase	Shunt or Compound	Series	Polyphase	Synchronous	Synchronous Polyphase	Synchronous Capacitor	Shaded Pole	Series Governor	Capacitor	Capacitor Start
Current Supply	AC	▨			▨	▨	▨	▨	▨		▨	▨
	DC		▨									
	AC or DC			▨						▨		
Duty	Continuous	▨	▨		▨	▨	▨	▨	▨		▨	▨
	Intermittent			▨						▨		
Unidirectional									▨	▨		
Reversible at rest only		▨				▨						▨
Reversible at rest or during rotation			▨		▨						▨	
Speed	Constant fixed	▨			▨	▨	▨	▨	▨		▨	▨
	Constant adjust		▨							▨		
	Variable			▨								
Starting Torque	Low							▨	▨		▨	
	Normal	▨	▨			▨						
	High									▨		▨
Starting Current	Low										▨	▨
	Normal	▨		▨	▨	▨	▨			▨		

keep them cool. At the same time grit must be kept out, since it would impair ventilating efficiency and cause shorts and grounds. A totally enclosed motor would generate too much heat. An effective fan, with especially designed baffling, places the cooling air where most required and keeps it moving at a sufficient velocity to carry out of the motor practically all the grit which enters. A filter in the cap covering the upper end of the motor keeps most of the grit from entering.

Other factors in the adaptation of the motor to this application include mechanical provision for the handles, switch and cord. The balance and weight of the motor had to be so selected as to give efficient motion to the working surface and smoothness of operation to the whole assembly. While there is great vibrational strain on internal parts, there is little vibration transmitted to the hands of the operator. The motor is of the series-wound type to provide the high speed required, and to permit operation on either alternating or direct current.

Uses Governor-Controlled Series Motor

Most of the tremendous strides made in the surgical profession during the last few decades would have been impossible without the concurrent development of suitable tools and apparatus. One of these developments is the surgical instrument illustrated in *Fig.* 2. Here the surgeon had the problem of obtaining a wide speed range and yet to be sure of plenty of torque at low speeds.

Only the series-wound motor provides the wide speed range required. Since the device is portable, and required in emergency cases, it must operate on both alternating and direct current. This universal operation is provided by the series-wound motor. The duty is sufficiently intermittent to make this type of motor adaptable. All series-wound motors, however, have one serious drawback to successful adaptation to this device—they lose their torque at low speeds when they are controlled by a rheostat.

The speed control problem in this application is solved neatly by the use of the electric governor. This governor is built into the motor, and the speed controlled by a knob, as shown, opposite the drive end. The governor requires a resistor and a capacitor connected across its contact points. These are conveniently located in the special base which firmly supports the unit against the torsional force of the flexible shaft. The operation of the contact points in the electric governor enables the series-wound motor to provide full torque at minimum speed as well as over the entire speed range.

Since delicate surgical work demands unusually low operating speed, a motor with integral worm-gear speed reducer was selected. Because ever-present fire hazard in operating rooms cannot be overlooked this motor is totally enclosed.

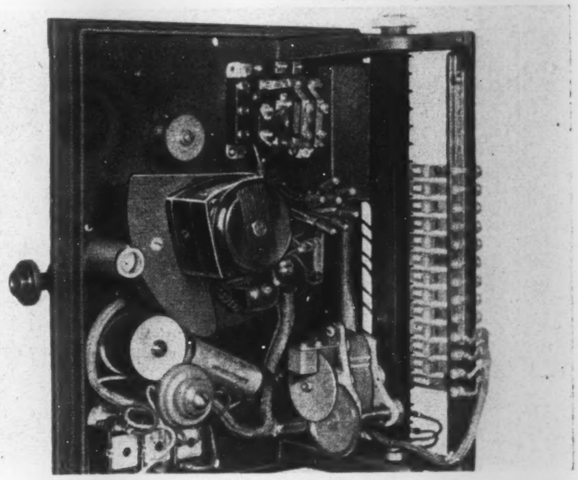
Small motors have many uses in the field of therapeutics, such as use of a split-phase induction motor in a portable lung. This is a relatively simple application, enabling the use of a standard motor. Dependability is the greatest factor to consider in choosing a motor for this device since motor failure may mean the difference between life and death for the patient.

The lung motor operates a bellows by means of a belt and pulleys, the load fluctuating widely during each cycle of the bellows movement. Being a portable device, it requires the lightest motor that will handle the maximum load, yet remain within normal operating temperature under continuous duty. This narrows the choice for a motor, of the approximate output rating required, to the split-phase or permanent-capacitor type.

Since the split-phase motor has about twice the starting torque of the capacitor motor, a size can be used which may be loaded more closely to its maximum output yet insure starting at any point in the cycle of operation

Fig. 3—Synchronous-capacitor motor provides power for timer in traffic signal control and requires little space

Photo, courtesy Crouse-Hinds Co.



which means less weight and greater portability. Since the split-phase motor is also one of the simplest in construction and one of the most dependable it is well suited to the application. Other considerations which favor the split-phase motor for operation of the portable lung are constant speed, relatively low speed as compared with the series-wound motor, and quietness. From the standpoint of quietness and cost, sleeve bearings were selected for this application.

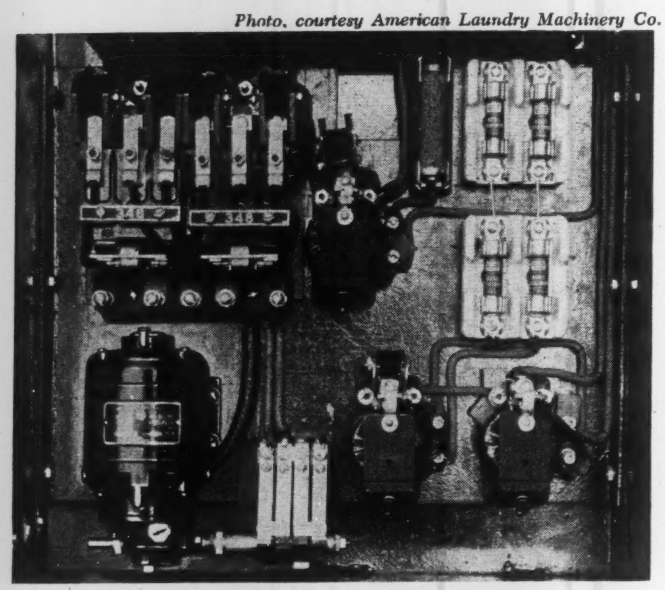
Wide temperature variations offer problems in small motor application not usually encountered with large motors. Selection of bearing, lubricant, and correct choice of limits for dimensional clearances between moving parts are important considerations. A typical application involving wide temperature range is the traffic-signal timer illustrated in ***Fig.* 3**.

While the power required to time traffic signals is small, the motors are depended upon to keep the system of signals synchronized with one another twenty-four hours a day, through all four seasons of the year. Because of the low speed of the timing cams these motors are geared down. The motor in the illustration has spur gears, which are more efficient than worm gears. Because of the small amount of power transmitted the entire gear train can be housed within a small envelope. Ball bearings were chosen because they will operate successfully at both extremes of temperature without great variations in internal friction, and without the necessity of allowing the abnormal clearances required with sleeve bearings.

To provide the smallest possible motor dimensions, it must have relatively high efficiency and the fewest possible internal parts. This, in addition to synchronous speed, is taken care of with a synchronous-capacitor motor. The motor, complete with integral gear reduction, has dimensions approximately 2⅜ inches square by 2¼ inches long. An external capacitor about the size of a man's thumb is mounted nearby. Mounting of the motor is by means of extended through bolts at the driveshaft end. Inside the motor proper, the rotor is the only moving part. Mounting and location of the motor is such as to facilitate accessibility for lubrication and replacement.

Fig. 4—Shaded-pole motor operates control for laundry machine. Timing of sequence operations requires a substantially constant speed of operation

Photo, courtesy American Laundry Machinery Co.



No discussion of small motor application would be complete without some mention of the shaded-pole motor. Most of us will recognize this motor in its most common application—that of operating small fans and blowers. However, outside the appliance field are many unique applications. It is often interestingly applied with integral speed reducer, either spur or worm. Inducements to its wide usage are its low cost and simplicity, making it unusually reliable in performance. It is used as a speed-reducer motor in recording and controlling instruments, temperature controllers, and various industrial timing devices. ***Fig.* 4** shows a shaded-pole worm-gear reducer motor applied to a commercial laundry controller.

This motor operates the timing cams which reverse the main motor driving a washer cylinder. The timing need not be as accurate as is obtained with a synchronous motor, but substantially constant speed is demanded. For instance, if the timing motor ran too fast, the main motor would reverse so frequently as to overheat. It is important that the cylinder run the same number of revolutions in each direction and reverse frequently enough to prevent the clothes from tangling and tearing.

It is apparent that the timing motor in this application must be capable of continuous operation within the normal temperature limit. It operates in a fairly high ambient temperature and in relatively high humidity. The motor is provided with special insulation to withstand this condition. A special driveshaft is provided to accommodate direct mounting of the timing cams.

Determining Load Requirements

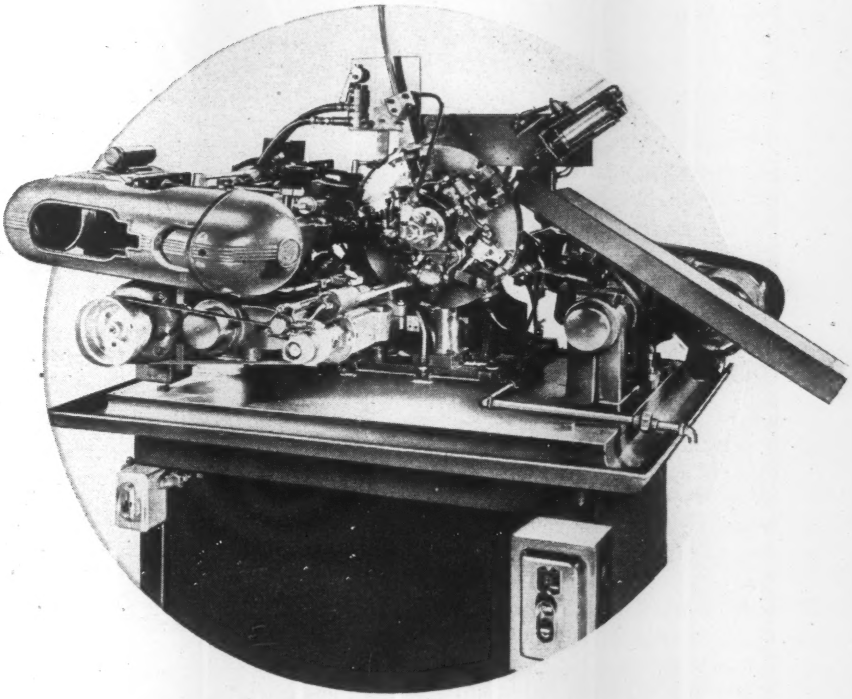
In applying small motors it is always important to bear in mind that they do not generally have the overload capacity of large motors and that temperature variations have a notable effect on their operating characteristics. The load of nearly every machine on which they are applied varies over different portions of its operating cycle. Therefore the maximum torque must be determined accurately. Allowance must be made for operation under low voltage conditions. Starting torque is usually the maximum torque encountered, and it is easy to measure. A simple method is the use of a pulley, string, and weights or spring balance.

The pulley is fastened to the shaft, and weights are loaded on a string wound around the pulley until the pulley turns when power is applied to motor. The torque in ounce-inches is found by multiplying the radius of the pulley in inches by the weight in ounces. A spring balance may be substituted for the weights, and the scale read just as the load moves. Allowance must be made for the weight of the scale.

Unless one has had considerable experience in the application of all kinds of fractional horsepower motors it is wise to present the problem to the motor manufacturer. This minimizes the chance of overlooking some important factors, as well as the necessity of repeated tests with various motors. Most motor manufacturers provide a convenient form on which the pertinent data can be presented.

Engineers' Symposium

This group of short articles discusses a few interesting drive and control features embodied in specific machines



Pneumatic System Indexes Machine

By K. H. Pond
Pond Engineering Co.
Springfield, Mass.

UTILIZING a pneumatic actuating unit, the automatic drilling and countersinking machine, illustrated above, drills and countersinks both sides of a cotter-pin hole in a ¼-inch diameter pin at the rate of 40 per minute. The control consists basically of a one revolution camshaft which opens and closes four 3-way air valves. Located in the base of the machine, the actuator has a manifold which connects each valve on its inlet side to high-pressure air supply. Outlet side of each valve is connected to one or more air cylinders mounted on the fixtures of the machine. These cylinders actuate the slides, levers, clamps and feeding mechanism for the automatic functions. Cycling speed is adjustable by turning a knob and the number of impulses and duration of impulse on each cylinder is regulated by removing, adding or respacing screws in the periphery of the cams.

Turntable indexing unit is cylinder operated and locked at each station. Its shaft is mounted on two rows of large, preloaded, tapered-roller bearings which contribute to smooth high-speed indexing of the unit.

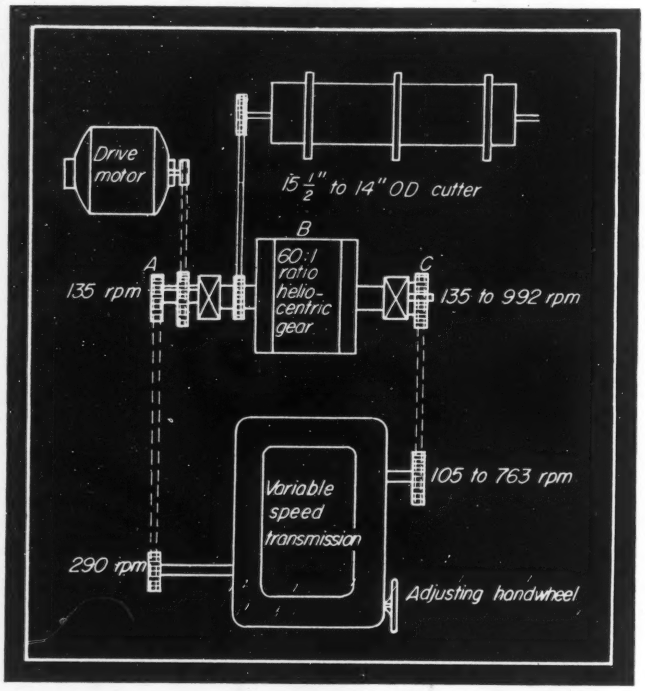
Precise Speeds from Gear-Tooth Splitter

By J. H. Gepfert
Reeves Pulley Co.
Cleveland

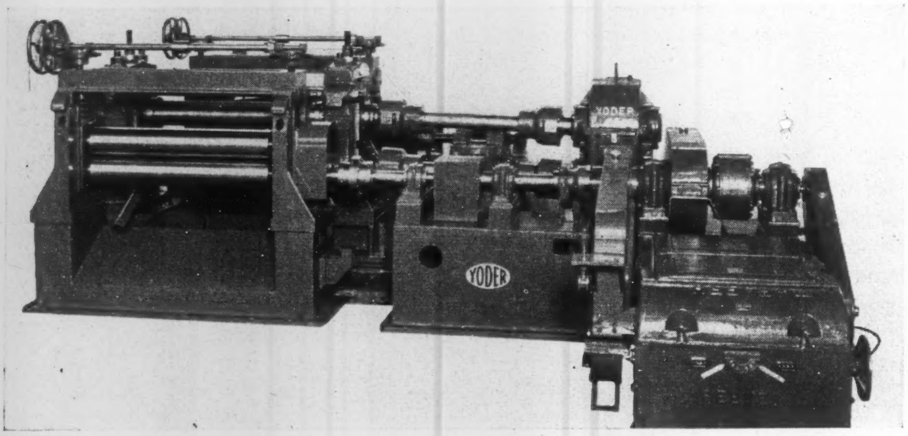
SUCCESSFUL operation of some types of continuous processing equipment depends upon the control of speed to an accuracy beyond that obtainable from standard variable-speed drives used in the normal manner. An example of this type of requirement is the synchronization of a feed-roll mechanism with cutter-slitter rolls.

To synchronize the feed to the cutters effectively for all conditions of operation, the speed control of the driving system must satisfy a number of basic requirements:

1. Feed rate of the material must be matched exactly with the cutter speed to prevent deformation of the material between the feed rolls and the cutter
2. System must be adjustable to the accuracy required, while in operation, to compensate for cutter and feed-roll wear and foreign material build up on the feed rolls
3. Available speed change must be wide enough to cover major diameter changes of the feed rolls and cutters, resulting from regrinding or sharpening
4. Speed adjustment must be accurately maintained over relatively long periods of time to eliminate the necessity of constant adjustment when no outside disturbing factors are present.



All of these requirements have been fulfilled successfully by using a synchronizing system composed of a Reeves variable-speed transmission and a gear differential or epicyclic gear train in multiple combination. The operation of the system is based upon the fact that the output speed of an epicyclic gear train may be varied by changing the speed relationship between the two input shafts.



A spur gear, planetary, differential or heliocentric type gear reducer may be used as the differential gearing by mounting it by the input and output shafts, with the housing free to rotate. This also allows choice of gear ratio to give the desired amount of speed-adjusting accuracy consistent with the overall change in speeds required to synchronize the rolls for maximum change in diameter.

The basic relationship of speeds between the two input shafts, the gear ratio of the reducer, and the output speed is

$$B = A + \frac{C - A}{R + 1}$$

where C = rpm of variable-speed input shaft, A = rpm of constant-speed input shaft, B = rpm of the output shaft, and R = ratio of gearing in gear reducer. These values are to be taken algebraically, one direction of rotation being considered positive. The normal input shaft and the case are considered as inputs.

By driving one input at a constant speed and the other at a speed which, multiplied by the gear ratio, is greater than the constant speed, the output will rotate faster than the input by the difference in speed between them.

An actual application to a feed roll drive for a slitter system is shown in the accompanying photograph and schematic diagram. If the cutters are to be reground from their 15½-inch diameter down to 14; and the feed rolls reground from an 8-inch down to a 7-inch diameter before being discarded, then the overall speed increase to maintain a given delivery rate will be $(15.5/14)(8/7) = 1.265$. A delivery rate of 282 fpm requires that the 8-inch feed roll revolve at $282 \div (8\pi/12) = 135$ rpm. Therefore the feed roll speed must range from 135 rpm minimum to $135 \times 1.265 = 171$ rpm maximum.

Speed-adjustment accuracy will be increased eight fold when a variable-speed drive is chosen that will change the speed of the controlled input shaft through a ratio of 8:1, while the output shaft changes speed from 171 to 135, a change of 36 rpm.

The variable-speed transmission must be driven from the constant-input shaft at a speed comparable to that of the input shaft. If the constant input shaft is driven at 135 rpm and the variable-speed transmission at 290 rpm, the output of the variable-speed transmission will be any speed from 763 to 105 for an 8 to 1 speed range variable drive. The controlled input shaft can then be driven at a speed of 992 to 135 rpm, which is consistent with the gear ratio of 60:1 to fulfill the basic speed relationship of the differential gearing. The extreme accuracy and the fineness of speed change possible with this system answers the need for slightly varying the relative speed of rolls as well as compensating for the grinding of any ground-surface pinch rolls.

Inertial Wheel Absorbs Shock

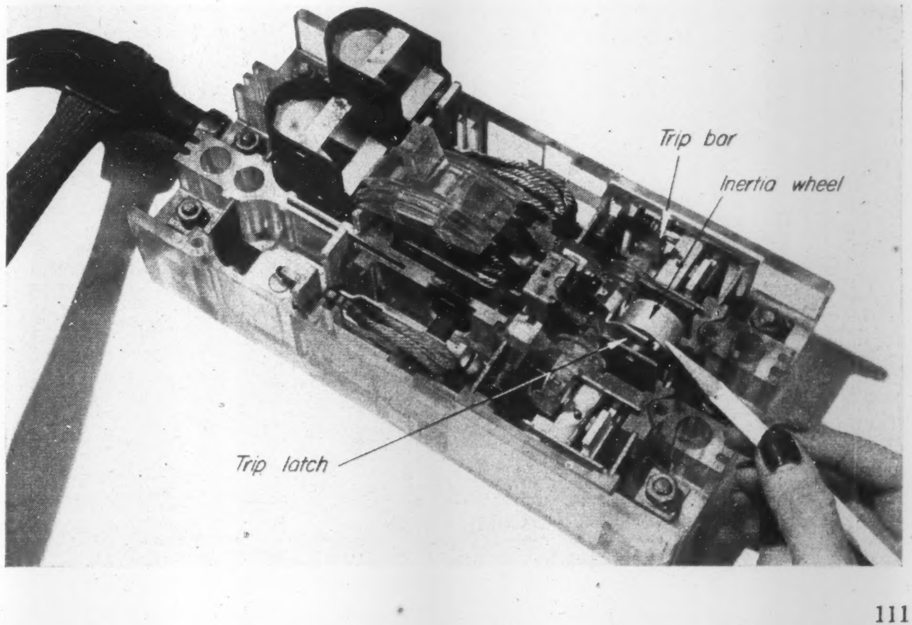
By H. D. Dorfman
Section Engineer
Westinghouse Electric Corp.
East Pittsburgh, Pa.

DISSIPATION of shock loads by transferring energy from one body to another makes possible a circuit breaker that will withstand mechanical impacts up to 200 foot-pounds. A fast-action, short-travel contact mechanism, which depends upon the overcenter principle, is utilized to effect this shock-resistant feature.

As can be seen in the illustration, the force of the hammer blow has been transferred to the inertia wheel by the trip latch. As a result, the wheel has rotated, leaving the trip bar in the on position. A second pin on the inertia wheel, located 180 degrees from the one at the pencil point, strikes the trip latch on the other side. Thus, the transfer of energy that again takes place keeps the trip bar tightly in the on position. Were it not for this final transfer of energy, the trip bar could conceivably rotate to the off position and consequently trip the breaker open.

This breaker is small and compact. It has a tripping mechanism that can be removed for changing the ratings. The trip unit is both thermal and magnetic: Thermal for inverse time delay to prevent tripping on harmless overloads, and magnetic above the starting currents of the various motors to assure fast tripping on short-circuit currents that would be harmful to the motor as well as the circuit wires. Since the breaker is generally used where there is frequent shock and vibration, heavy short-circuits might be encountered and the interrupting capacity is therefore 15,000 amperes at 600 volts ac . This high interrupting capacity is accomplished with a specially-designed fast-action contact mechanism, with special contacts and a Deion arc extinguisher, which makes possible rupturing high currents with a small break. This breaker is also provided with special studs, making possible removal from the front of the panel without disturbing rear studs, busses and hot terminals. It is only necessary to loosen mounting screws and the breaker can be lifted from the hot bus without danger.

The removable trip mechanism was kept narrow in



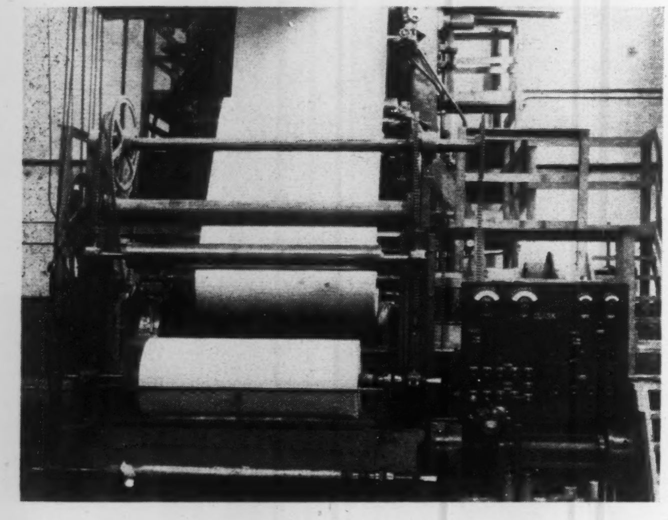
width by placing the contact arm on edge, and short in length by using the overcenter principle. Indirectly heated thermal elements for the thermal trip are used to conserve width and length. Because of space limitations, glass-insulated wire is used in the coils of the magnetic circuit to insure the current carrying capacity required. As a result, higher operating temperatures can be used without danger to the insulation.

Controls Tension on Winder Drive

By J. L. Van Nort
Paper Mill Application Engineer
Reliance Electric & Engineering Co.
Cleveland

ENGINEERED electrical drives, in addition to supplying the proper kind of power at desired speeds, are capable of assuming or supervising many of the functions of the machine itself. These functions are performed more accurately and more productively than could be accomplished mechanically. This versatility is well exemplified in the application of engineered electrical drive to the supercalender (paper-finishing machine) illustrated, which has a drive more complex than the machine itself.

The supercalender consists of a vertical stack of rolls, alternately highly polished steel and composition material which are held under pressure. Paper from an unwind stand passes through the rolls to a rewind stand and in so doing receives a fine smooth finish. Different grades and weights of paper are handled at varying pressures. Hence the first requirement of the drive is to provide variable speeds over a fairly wide range. This is accomplished in the Reliance system by a variable-voltage arrangement, shown schematically. An ac motor using line power drives a dc generator, the output of which can be varied so as to control the speed of the dc motor driving the calender. Stepless speed changes are effected by a motor-operated rheostat which responds to the actuation of an operator's fast-slow pushbutton. The rheostat has independently-adjustable rates of travel in both directions so that smooth acceleration and deceleration at optimum rates can be preset, according to requirements.



Speed below the operating range is also required for threading the material through the machine, an operation which takes place as often as three or four times an hour —whenever rolls are changed. This is supplied by a self-excited auxiliary field on the calender generator, which comes into play only at threading. This auxiliary field inherently holds low voltage for threading within close limits.

Quick stopping is also desirable, to minimize overtravel, waste and damage to rolls in case of a weak spot or break in the web. This is provided by regenerative braking. Pressing the stop button returns the motor-operated rheostat to the off-position rapidly, first strengthening the field of the calender motor, then reducing the voltage of the calender generator so that the motor acts as a braking generator, pumping power back into the line.

Two characteristics are required by the rewinder which takes the paper being delivered by the calender stack. The winder, obviously, must synchronize exactly with the calender operating speed. In addition proper tension must be maintained in the web to prevent wrinkles, overshooting, slack and breakage.

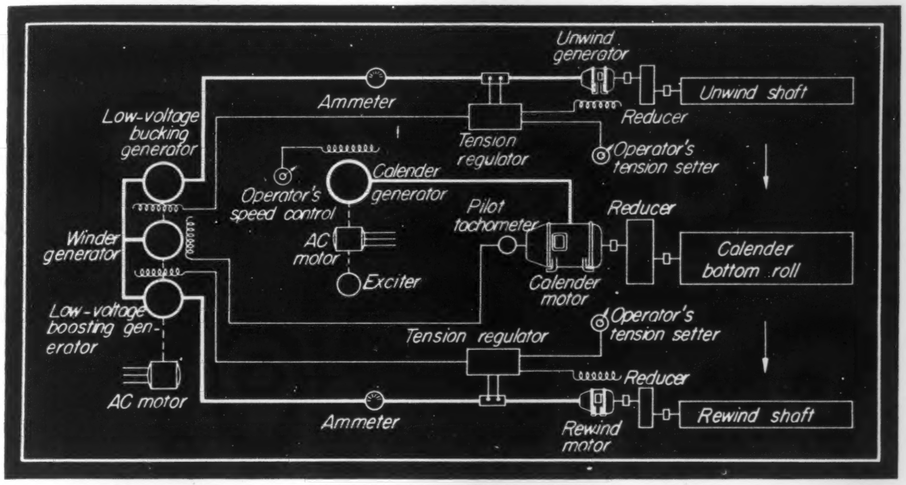
As the diameter of the roll builds up, winder speed must be proportionately reduced to maintain synchronization. A constant-horsepower field-control motor is used, field strength of which is continually adjusted automatically to maintain a constant-horsepower input.

So that the speed of the winder motor will respond to changes in operating speed, a voltage proportional to the speed of the calender is impressed on the motor armature. A reference source of variable voltage is supplied by a separate auxiliary motor-generator set, the field of the generator being controlled by a pilot tachometer driven by the main calender drive. As the calender speed changes, the field strength of the auxiliary generator changes in direct proportion and its output also changes in proportion, since it is being operated over the straight-line portion of its voltage curve.

For the maintenance of stalled tension when the machine is at rest, a small low-voltage booster generator permits application of a low voltage to the winder motor armature when the calender motor is not operating.

A constant value of tension when operating is provided by an automatic regulator which gets its signal from the voltage drop across a resistor in the armature circuit of the winder motor and controls the field strength of the latter to maintain constant armature current. The regulator, in addition, automatically controls the booster-generator voltage output for proper stalled-tension current.

A further refinement insures a stable value of tension during acceleration and deceleration. When the calender is accelerating, the winder motor must supply additional


Unwind generator
Ammeter
Unwind shaft
Low-voltage bucking generator
Reducer
Tension regulator
Operator's tension setter
Operator's speed control
Calender generator
Pilot tachometer
Reducer
Winder generator
AC motor
Calender bottom roll
Exciter
Calender motor
Low-voltage boosting generator
Operator's tension setter
Tension regulator
Reducer
AC motor
Ammeter
Rewind motor
Rewind shaft

power to overcome the inertia of the roll being wound, and hence extra input must be made to this motor. This is provided automatically by WR^2 compensation in the regulator which is brought into play whenever the fast button is pressed, which in effect resets the regulator to call for a higher value of current for the winder motor. A similar compensator works in reverse for slow down.

Tension must also be maintained in the unwind stand, and this is provided by a drag generator on the unwind shaft, the output of which is maintained constant by action of a tension regulator. The output of the drag generator is pumped into the auxiliary generator which supplies reference voltage for the former as well as the winder motor.

Control of all functions is centered in an operator's station with pushbuttons, switches, tension-setting rheostats, ammeters, and tachometer. Starting the calender at threading speed, paper is fed through the rolls and the unwinder tension-on switch is thrown. The paper is then carried through and pasted to the winder core, and winder tension established by setting the switch. The complete equipment goes into action at threading speed when the start button is pressed, and operation at any point in the 50 to 2000 fpm speed range is achieved by holding down the fast or slow button for controlled acceleration or deceleration. The emergency-stop button brings all equipment to rest in the shortest possible time. Four rheostats permit the independent setting of winder and unwinder both for stalled and running tension conditions of operation.

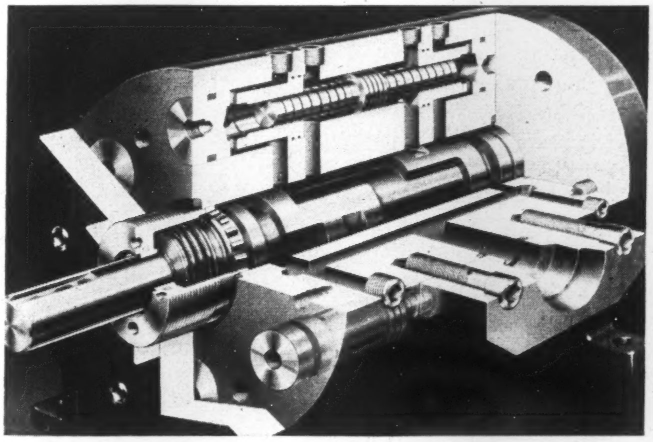
To calender operation, this electrical drive contributes optimum operating speeds and conditions for the highest production rates of quality finish, while reducing to a trouble-free, minimum time the frequent shut-down, start-up cycles encountered in this work.

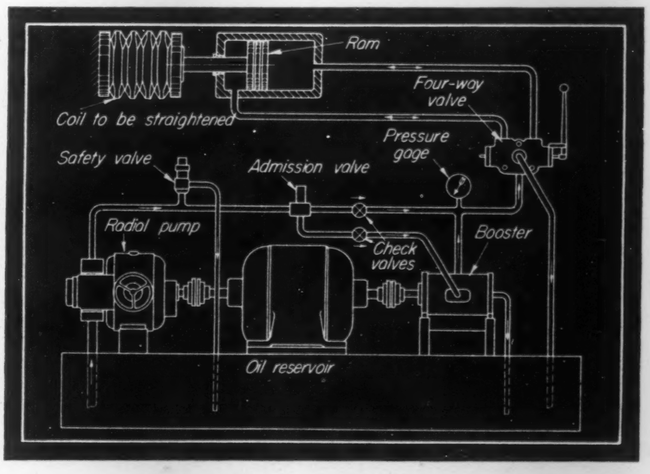
Hydraulic Booster Reduces Cycle Time

By George M. Geiger
Chief Engineer
Hydro-Power Inc.
Springfield, O.

DUAL-PRESSURE hydraulic system, utilizing a pump to provide high volume at low pressure for rapid speeds at low load and a booster to produce high pressure for squeeze, has been employed to advantage on a coil straightening press. Operation is obtained with simple control, and the pump used is of economical design.

The problem for which this system provided the solution involved press straightening of large copper-bar windings for assembly as coils in large generators. The copper material is of rectangular section with the long dimension perpendicular to the axis of the rectangular coil. The




Ram
Four-way valve
Coil to be straightened
Pressure gage
Safety valve
Admission valve
Radial pump
Booster
Check valves
Oil reservoir

strain of winding such a heavy section of this ductile material introduces a distortion of the bar form at the small-radius corners. At the extreme radius, the bar section tends to thin, while the inner section swells, so that the area tends to "pyramid", resulting in a cumulative effect which lengthens the coil beyond the assembly dimension, while leaving air gaps at thinned-section locations. For satisfactory assembly this distortion must be eliminated by a high-pressure squeeze of the coil.

Total force of three hundred tons was required to handle the work involved and a method was sought for avoiding the penalty of a slow cycle which would result with a conventional high-pressure reciprocating-plunger pump powering the hydraulic system. The dual-pressure system, illustrated in the circuit diagram, utilizes a radial pump in conjunction with a 3:1 ratio booster, shown in cutaway view. These power units are connected to each end of the driving motor. Very little system horsepower is absorbed by the booster, incidentally, rotational power being required only to revolve the central booster valve, which channels oil received from the pump to the six reciprocating plungers.

During traverse, an 11 gallon-per-minute pump operates direct on the ram for high speed opening and closing of the press. When the work is contacted and resistance encountered, an admission valve channels the pump output through the booster, and 6200 psi is provided at 3.66 gpm flow.

Dashpot Operates Controller

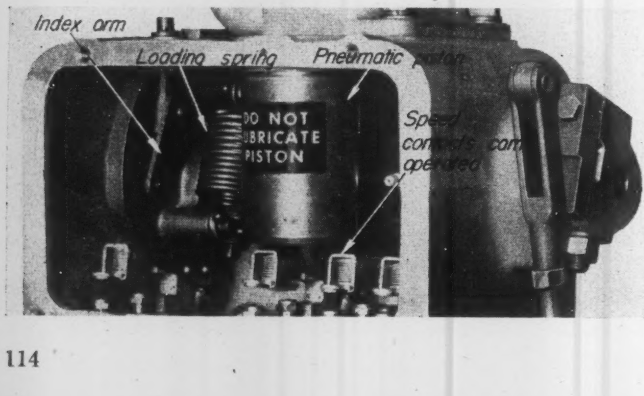
By B. I. Ulinski
Chief Engineer, Truck Div.
Automatic Transportation Co.
Chicago

In recent years it has become increasingly preferred design to utilize magnetic mechanisms for operating heavy-duty switches in the motor-control system on electrically powered industrial trucks. Magnetic contactors, controlled with a properly-designed master controller, contribute to safe foolproof operation.

In designing a control for trucks, the object was to develop a simplified system with a minimum number of contactors. Consequently a magnetic contactor was used wherein contacts were bridged in both energized and de-energized positions. With four such contactors it becomes possible to control the directional motion, inching and required four-speed positions by the actuation of predetermined combination of switches in the controller.

The master controller is designed in two sections—a directional control switch and a speed-control mechanism. This permits use of the directional switch in combination with reversing contactors as a controlling device for truck motions, such as lifting and tilting, requiring single speed.

The directional switch and speed control section are electrically interlocked with each other and with the magnetic contactors so that each section functions independently without need of resorting to the use of mechanical interlocks to meet required safety standards.



Switch contacts in the controller are coin-silver tipped and are actuated by molded canvas-filled phenolic-plastic cams riding on case-hardened rollers. These hardened rollers rotate on 18-8 stainless-steel pins.

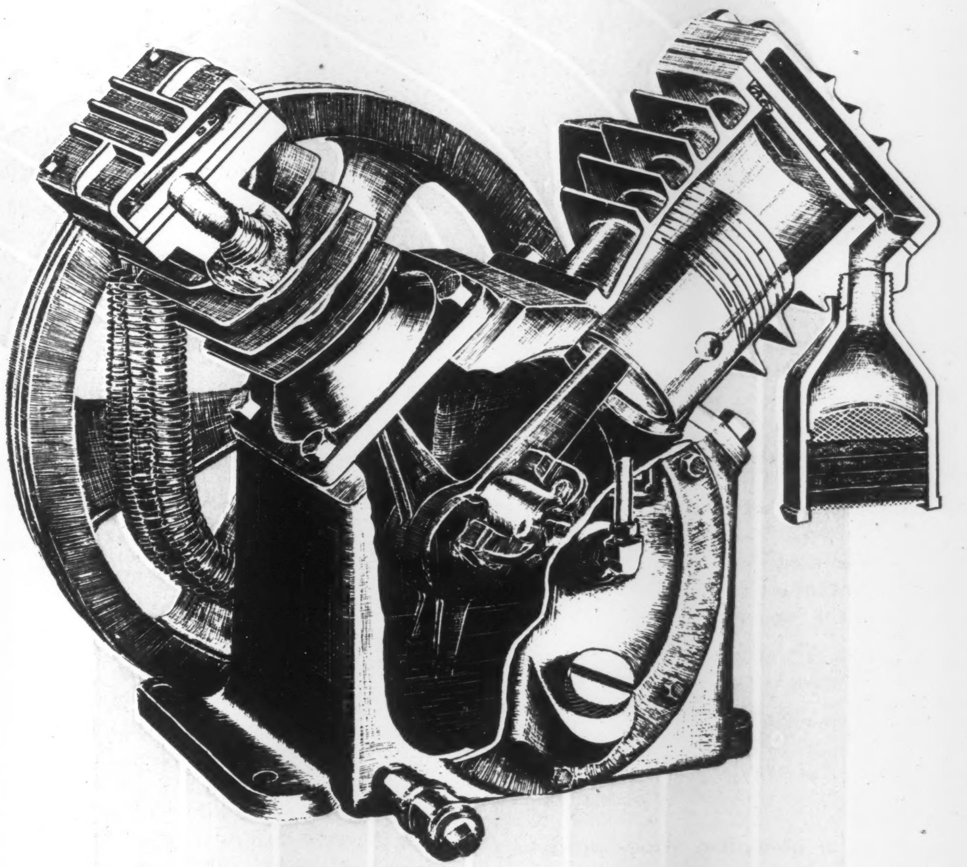
Timing of the switch contacts is accomplished by a spring-energized pneumatic-piston type dash pot, controlling the rotational movement of the switch cam assembly. The dash-pot-loading spring is of the tension type and is energized by pulling down the speed-control lever. Stored up energy in the stretched spring is thus dissipated slowly by the retarding action of the piston in the dash pot. A fixed-size hole in a removable air-jet disk admits filtered air to the cylinder.

The dash-pot piston is soft graphite-carbon material and ordinarily operates in a precision-machined phosphor-bronze cylinder. Since the coefficient of expansion of graphite and phosphor bronze is different, the phosphor-bronze cylinder is used only where the truck is operated indoors. If extremes of operating temperature are encountered, the cylinder is fabricated from a special high-nickel content alloy steel, the coefficient of expansion of which—from zero to 400 F—conforms closely to the graphite material of the piston.

The controller and switch cases are cast aluminum. Threaded bronze inserts are installed in all tapped holes. Internally operating indexing arm is a precision plaster-mold casting of an aluminum-bronze alloy requiring little or no machining. A case-hardened steel roller rotating on an 18-8 stainless-steel pin engages the cast grooves in the indexing arm.

Controller shaft is polished and ground shafting, rotating on needle bearings. The cam sleeves also rotate on needle bearings. Since the controller shaft oscillates through an operating range of only 36 degrees, the lubricant originally supplied will last a long time.

Other points that have proved satisfactory and trouble-free is a steel clock-spring which returns controller to neutral position, and wedge-type bolts which keep the various mountable members in fixed position without resorting to keys or other locking devices.



Designing for Pneumatics

Part I—General Considerations and Compressors

By James L. Dooley
Consulting Engineer
Venice, Calif.

AIR—the mixture of oxygen, nitrogen, argon, and a trace of carbon dioxide existing for a practical depth of about ten miles over the face of the earth—was one of man's first means of transmitting power and exercising remote control. It has only been in recent years, however, that its potentialities have come to be appreciated fully.

The possible advantages of compressed air as a means of doing a given job are:

1. Air is universally available and the supply inexhaustible
2. No return lines (or wires) are needed as with other methods of transmitting control or power and line size is smaller than for fluid

3. There is no direct fire or shock hazard. Although air is not inflammable it would, of course, aid a fire

4. Compressed air energy can be stored in reasonable quantity. The air receiver is the simplest, lightest, cheapest, most reliable, and generally most compact means of storing energy in use today. All lines and incidental volume in the system become part of the receiver

5. Rate of response is high because air has little inertia. The first impulse travels at the speed of sound, but actual air for power is slower (200-300 feet per second)

6. Equipment generally is simple so average maintenance personnel can understand it

7. Rotary motors are light and rugged. They can be reversed easily and can stall indefinitely under load without damage

8. Compressed air lends itself to linear motion by use of a cylinder and piston

9. Viscosity change with temperature is insignificant, making air ideal for accurate control

10. Being nontoxic, air can be used for ventilation or cooling

11. No danger or mess results when air is dumped in quantity

12. Since it is compressible, air has cushioning characteristics

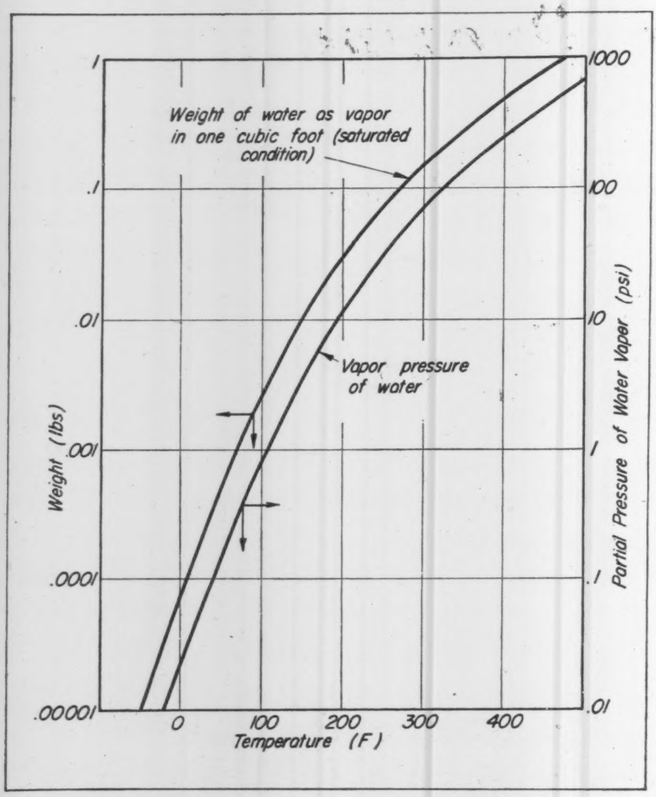
13. Oxygen content can be used

14. Air can be used as a jet for such things as sweeping, conveying, paint spraying, chip removal, etc.

As with every other means of transmitting power, compressed air has its disadvantages. In general these are:

1. Efficiency is low. Frequently the overall efficiency from the compressor input shaft to the air motor output shaft is below 15 per cent, especially in industrial plants where upkeep is not at its best. This means that compressed air is not practical for a high power *continuous* duty job

Fig. 1—Chart giving data for estimating vapor pressure and water content of air



2. Compressibility, generally most serious to those not acquainted with actual applications with proper valves, is sometimes a definite disadvantage

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WITH THIS ARTICLE MACHINE DESIGN launches an outstanding series for the designer of machines who contemplates using pneumatic power or control. The author, a consulting engineer in pneumatics who has long been associated with the design and manufacture of pneumatic equipment, takes the designer from a brief review of general theory through compressors, system pressures, storage, transmission, power uses, and control applications, outlining salient characteristics, advantages, limitations, and design problems attendant to the utilization of compressed air

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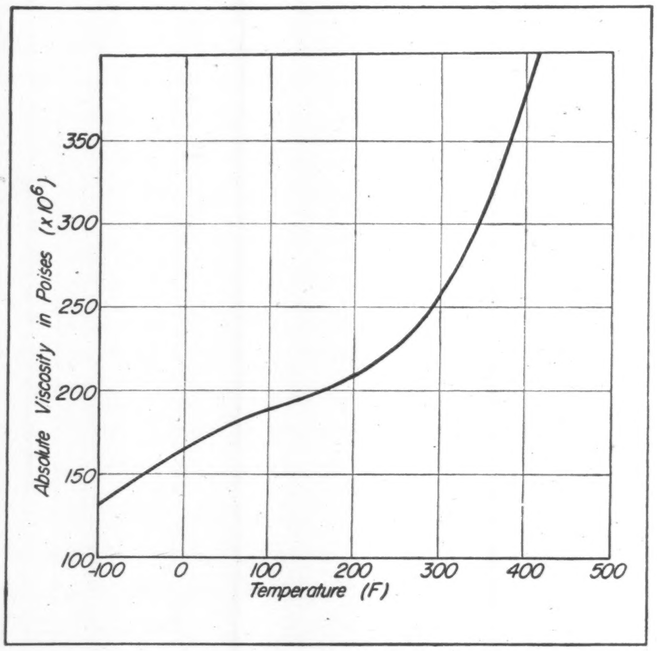
3. Leakage is only critical in systems where very little compressor capacity is available, such as aircraft systems, service station systems, and truck air brake systems, but in any system it is inefficient

4. Explosion hazard exists wherever pressure is used, but if proper caution is taken in the tubing, pipe, and fittings used, and if ASME code receivers are used, it is not serious

5. Generally there is not enough oil in compressed air to

Fig. 2—Effect of temperature on the viscosity of air



lubricate cylinders, valves, and motors so they must be designed for either self or nonlubricated operation.

Since air is a mixture of gases it can be treated as a gas in most calculations. Therefore it follows the fundamental thermodynamic equations of state for a perfect gas within all practical pressures and temperatures:

$$PV = WRT \quad \text{.......... (1)}$$

where P = absolute pressure in pounds per square foot; V = volume of gas in cubic feet; W = weight of gas in pounds; R = a constant equal to the mechanical work done by the expansion of unit weight of the perfect gas at constant pressure while heating one degree F—in foot pounds per degree F per pound. It is also equal to the universal gas constant divided by the molecular weight or $1544 \div 28.8 = 53.3$ for air; and T = absolute temperature (degrees F + 460).

In nature, water is present in all air to some extent. This water must be controlled or removed in many applications of compressed air before the air can be used. Mist or water particles can be settled out or removed by mechanical means, but the water that exists as vapor in the air must be condensed before removal. The water vapor content of compressed air can be determined by the law of partial pressures—partial pressure of the water vapor plus the partial pressure of the dry air equals the total pressure of the mixture. Since the maximum partial pressure of the water vapor is a function of temperature only, being equal to the water vapor pressure at the given temperature as shown in *Fig.* 1, the water vapor content of compressed air when cooled is not serious for most applications. The condensed liquid water need only be collected and drained. If normal cooling will not remove enough moisture for some special application such as hot air drying of refrigerating systems prior to filling with refrigerant, or pressure testing aircraft oxygen systems, several things may be done: (1) The total pressure can be raised to increase the partial pressure of the air; (2) Refrigeration can be used to lower the water vapor partial pressure (see *Fig.* 1); (3) Chemical dessicants can be used. Weight of water existing as vapor in a cubic foot of saturated compressed air under varying temperature conditions is shown in *Fig.* 1. The weight of air in the same cubic foot is:

$$W_a = \frac{2.7}{T}\left(p_{mix} - p_{water\ vapor}\right) \quad \text{.......... (2)}$$

In changes of state, such as compression or expansion, of a perfect gas such as air the following equation applies:

$$PV^N = WRT = K \quad \text{.......... (3)}$$

where K = a constant. If a change of state is made without a temperature change during the process, the conditions are termed *isothermal* and N must equal unity. If the change of state is made without the addition or subtraction of heat, the conditions are *adiabatic* and N equals the ratio of specific heats at constant pressure and constant volume (1.3947 for air). Commercially it is impractical to follow either of these conditions exactly, but because most actual changes of state in air occur in an extremely short time, the conditions are very nearly adiabatic. In view of this the following equations expressing the relations between pressures, volumes, and tempera-

Fig. 3—Three-stage, Vee type, air-cooled, V-belt driven air compressor for 2000 psi, light-duty service

Photo, courtesy Ingersoll-Rand Co.

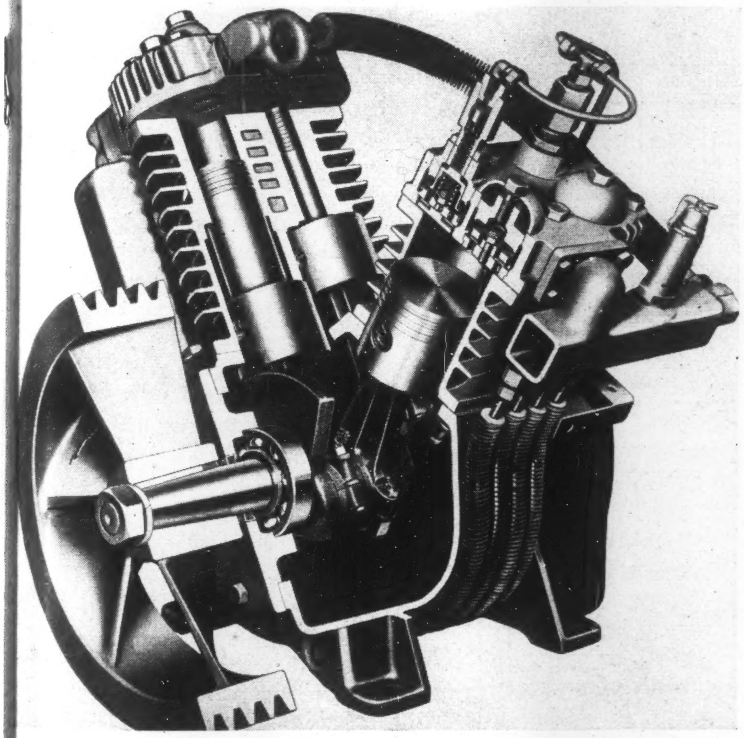
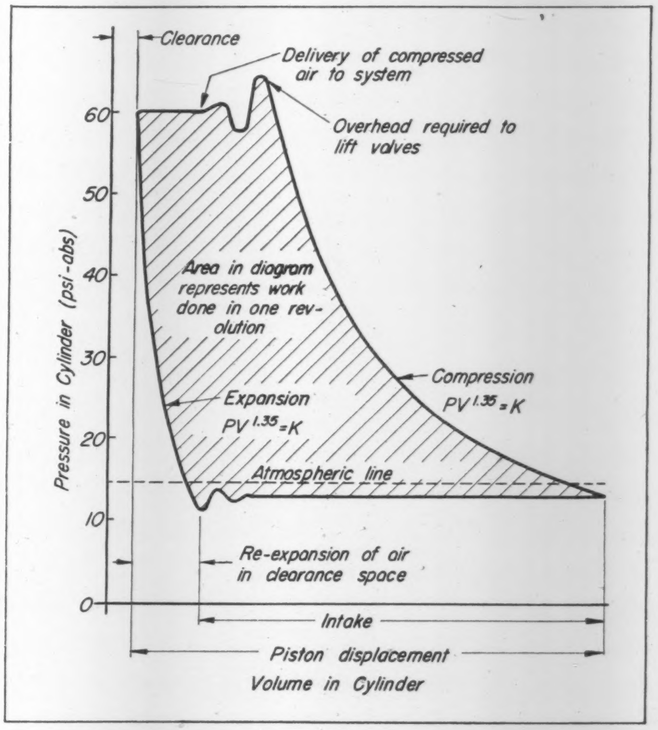


Fig. 4—Pressure-volume indicator diagram for single-stage, single-acting, medium-speed air compressor with atmospheric intake



tures for adiabatic compression or expansion of air are useful. They are all derived from Equation 3 with subscripts 1 and 2 denoting the before and after conditions:

$$\frac{P_2}{P_1}=\left(\frac{V_1}{V_2}\right)^{1.395} \quad (4)$$

$$\frac{V_1}{V_2}=\left(\frac{P_2}{P_1}\right)^{0.717} \quad (5)$$

$$\frac{V_1}{V_2}=\left(\frac{T_2}{T_1}\right)^{2.534} \quad (6)$$

$$\frac{T_2}{T_1}=\left(\frac{V_1}{V_2}\right)^{0.395} \quad (7)$$

$$\frac{P_2}{P_1}=\left(\frac{T_2}{T_1}\right)^{3.534} \quad (8)$$

$$\frac{T_2}{T_1}=\left(\frac{P_2}{P_1}\right)^{0.283} \quad (9)$$

It is also of interest to note that the viscosity of air is sensibly independent of the temperature; that it drops with the temperature (*Fig.* 2) and that the air itself is useful over an extremely wide range of temperatures, i.e., it does not freeze.

Air Compressors: A compressor is any device used to reduce the volume of a given quantity of air and in so doing increase the pressure it exerts on the walls of its containing vessel. There are two basic types of compressors in use, although others may exist: (1) Pulsating-flow positive-displacement compressors which trap a quantity of air in the machine at intake pressure or below and then reduce its volume, finally discharging the air into the higher pressure system. All reciprocating types as well as the rotary sliding-vane and lobe types fall into this classification. (2) Uniform-flow compressors which make use of the fact that air is a compressible fluid having mass. Centrifugal and axial-flow fans, blowers, and compressors fall into this classification. Actually, flow from these machines may pulsate slightly in some designs and at some flow conditions. Generally these are low-pressure machines, although multistage centrifugal compressors have been built for atmospheric intake with 110 to 125 psi gage discharge pressure and axial-flow units designed up to a compression ratio of 10.

To the author's knowledge compressors have been built with capacities from a few cubic inches of free air per minute up to 120,000 cubic feet. Others have discharge pressures as high as 25,000 psi gage, some using seven stages of compression. The brake horsepower range is from about 0.02 to 15,000 per unit. Because many applications require small quantities of compressed air at relatively high pressures, reciprocating piston type compressors are usually used, *Fig.* 3. The following discussion will refer specifically to this type but it applies to the others.

The graph, *Fig.* 4, shows the pressure existing in the cylinder of a single-stage reciprocating compressor throughout one revolution. The *N*-value for the diagram was taken as 1.35 instead of 1.39 because of cooling of the cylinder walls and head with water jackets or cooling fins. If *all* of the heat could have been removed, the *N*-value would be unity, the area of the indicator card would be less and the horsepower required to drive the compressor also would be less. The overhead (discharge) and undertow (intake) losses due to valving become serious with high-speed compressors (1800 rpm and above) such as are being used in aircraft. The overhead also is more critical at very high pressures as in the last stage of a three or four-stage compressor because the rate of pressure rise at the time the discharge valve must open is extremely high. This overhead not only means loss of efficiency, but higher discharge temperatures.

High temperatures cause more carbon formation (from lubricating oil) and carbon will eventually cause malfunctioning of the valves. Because of these difficulties, the lift area of the valves should be as large as practicable, valves and springs should be light and valve springs of proper tension. The valves are probably the most critical part of any compressor. Work done on the air each revolution is equal to the shaded area shown on

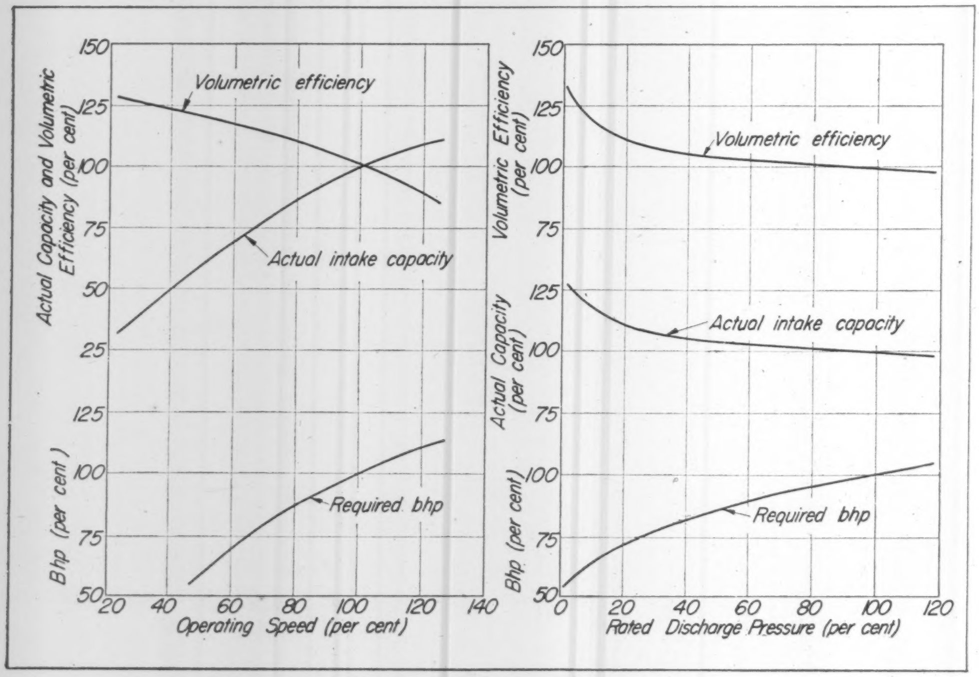


Fig. 5—Typical compressor characteristics based on a two-stage unit at sea level at rated discharge pressure

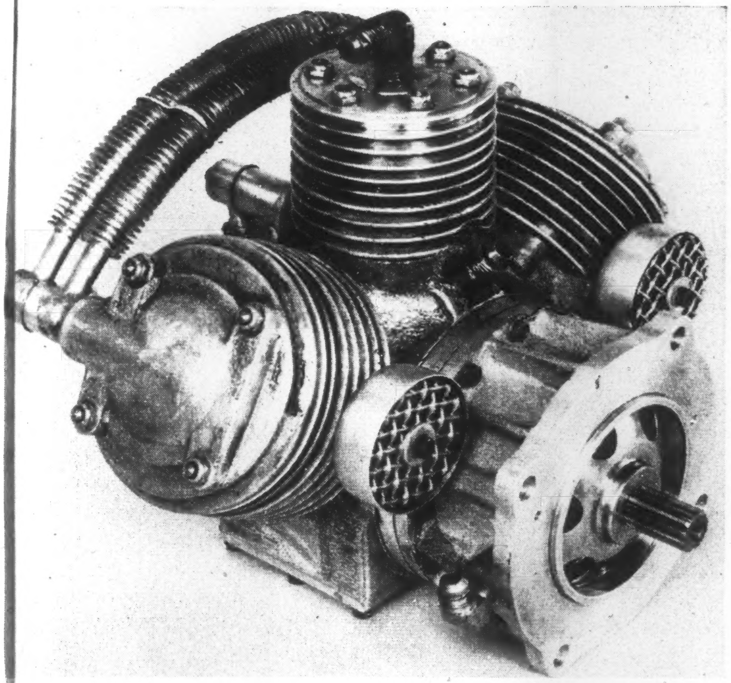


Fig. 6—Engine-mounted, two-stage aircraft compressor handles 6 cubic feet of intake air per minute at 1000 psi discharge pressure, is air cooled and weighs but 17 pounds complete with pneumatically operated clutch

the graph (indicator diagram). From this the power required for a compressor is:

$$Bhp = \frac{P.D. \times V.E. \times A.bhp}{100 \times A.C.E. \times M.E.} \quad \text{.......................} (10)$$

where Bhp = brake horsepower input; $P.D.$ = piston displacement in cubic feet per minute; $V.E.$ = volumetric efficiency, usually 40 to 90 per cent depending on speed, size, and type of compressor, which is equal to the ratio of actual intake capacity to the volume swept out by the piston; $A.C.E.$ = adiabatic compression efficiency which is anywhere from 50 to 80 per cent depending on speed, size, type, and condition of compressor; $M.E.$ = mechanical efficiency which is usually 85 to 95 per cent; and $A.bhp$ = adiabatic bhp factor.

The adiabatic brake horsepower factor is:

$$\frac{Bhp}{100\,cfm} = \frac{P}{2.292} \times \frac{N}{N-1}\left(r^{\left(\frac{N-1}{N}\right)} - 1\right) \quad \text{..........} (11)$$

where P = intake pressure in psia (absolute); N = 1.3947 for air; and r = ratio of compression.

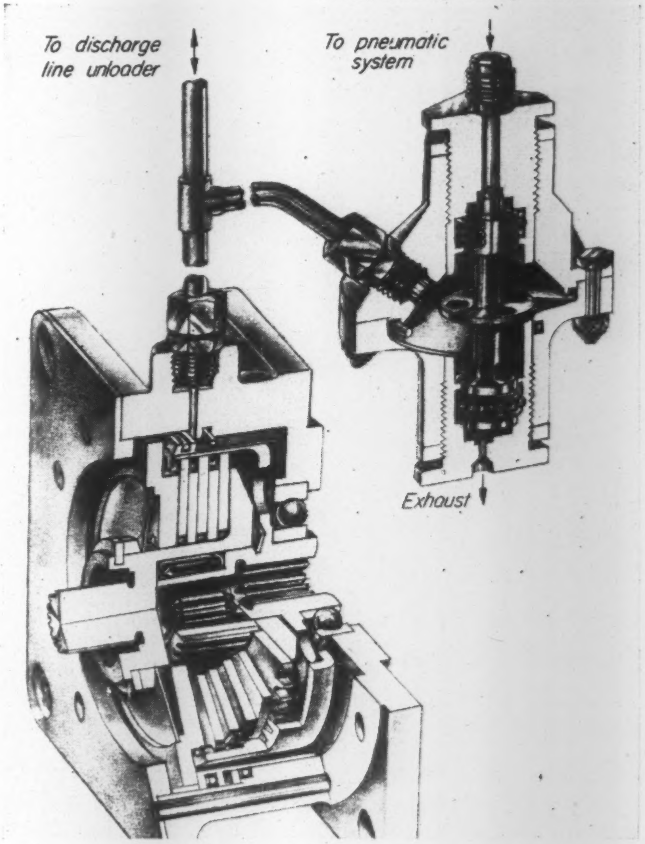
The ratio of compression in one stage is limited by: (1) Maximum allowable temperature in the cylinder at which lubrication can be maintained and carbon formation held to a minimum, and (2) minimum practical clearance in the cylinder. Clearance is the remaining space in the cylinder and valves when the piston is at top dead center. Volumetric efficiency is adversely affected by both an increase in clearance and an increase in compression ratio. At high compressor speeds the inertia of the air column and the inertia delay in valve movement must also be taken into account in determining volumetric efficiency.

To avoid some of these difficulties multistage compression is used with cooling of the air between stages (intercooling). This not only reduces the operating temperatures but lowers the required brake horsepower and permits a higher volumetric efficiency for each stage. It also eliminates the necessity of building each cylinder and its running gear rugged enough to handle full discharge pressure. In practice, compressors with atmospheric intake seldom use a compression ratio greater than 10 per stage and usually less. At sea level a two-stage compressor with 100 psi gage discharge pressure has a ratio of compression of about 2.8 per stage. Cylinder diameters are generally selected to balance the work required in each stage when temperature and piston loading permit. The differential pressure is not the same in each stage. As the intake pressure increases on any stage the maximum practical ratio of compression per stage is reduced to keep reasonable differential pressures across the piston. Characteristic performance is shown in *Fig.* 5.

Air compressors are usually driven electrically either direct or through gears or belts, although almost every type of motive power has been applied. Regardless of the type of drive, regulation of the output from the compressor must be provided. When the compressed air system is at a predetermined maximum pressure, the flow of compressed air into the system must be lowered or

Fig. 7—Lightweight regulation system for aircraft compressors similar to that in Fig. 6. At predetermined pressure a snap-action three-way valve applies pressure to the annular clutch-actuating piston, declutching the compressor from the engine

Photo, courtesy Harvey Machine Co.



stopped. To *reduce* the flow of compressed air to the system several expedients are used singly or combined:

1. Compressor rotative speed may be altered if driven by a variable-speed device
2. Inlet can be partly closed, throttling the air and causing reduced pressure at the inlet. This is inefficient
3. Clearance in the cylinder may be increased by opening one or more "pockets" in the head. This lowers the volumetric efficiency by leaving more compressed air in the cylinder to re-expand, but only slightly lowers the compression efficiency. This is the most widely used method on large commercial units
4. Inlet valve can be held open during the first portion of the compression stroke, forcing some of the air back out the inlet. The valve is then allowed to snap shut and the compression proceeds normally except that the amount of air in the cylinder is reduced
5. The least acceptable way to control the flow to the system is to allow the compressor to pump full capacity and dump some of the air from the compressor to atmosphere through a valve.

To *stop* the flow of compressed air to the system:

1. The compressor can be stopped, *Figs.* 6 and 7
2. Inlet valves may be held open continuously to allow the air to surge in and out of the cylinder with each stroke
3. Intake line or the intake valves may be closed
4. Discharge line may be opened to atmosphere and a check valve used to hold the air in the receiver or system
5. Clearance of the cylinder may be greatly increased by means of clearance pockets
6. In some special applications the compressor and system can be designed so that the discharge pressure can rise to the point where the volumetric efficiency of the compressor is zero. This is a variation of the clearance type of unloading mentioned—the pressure varies instead of the clearance volume.

Compressed air available for the pneumatic operation or control of machines is usually at 90 to 125 psi and inasmuch as small quantities of higher pressure air are sometimes required, the pneumatic ram is of interest. This uses the power from air which it expands back to atmosphere in order to compress some air to higher pressure. Pneumatic rams usually comprise one piston of two diameters with automatic valving for reciprocation.

Another class of compressor that has been finding more use in recent years is the nonlubricated type. Most compressors, whether the trunk-piston type or the large industrial crosshead type, put oil into the compressed-air system. Although this amount of oil is small and in some machine systems is advantageous, it cannot be tolerated for such applications as boiler control, paint spraying, blast cooling of searchlight lamps, etc.

Clean, Dry Air Expensive

Nonlubricated compressors may use rubbing materials that do not require lubrication such as carbon-graphite, certain plastics, and sintered porous metals or they may be made of conventional materials with water, soap water, or other compounds as a substitute lubricant. Oil and water-free air can only be had with additional expense and complication and is not necessary for the great majority of applications. In fact, compressors have been built with oil or water deliberately injected in quantity into the cylinder proper to effect better cooling of the air during the compression stroke. By distributing particles of cold liquid throughout the air charge, the heat of compression can be more readily absorbed, the temperature in the cylinder is less, so the effective N-value in Equation 11 would be approximately 1.0 instead of 1.4. The power required would be less and the disastrous effects of high temperature would be eliminated. This type is used very little at present because of the difficulties in removing the resultant oil or water mist from the compressed air.

The use of compressed air systems in aircraft has brought new design problems because of weight and space limitations as well as reduction of inlet pressure with altitude. The units shown in *Figs.* 6 and 8 are intended primarily for aircraft service. The two-stage 1000-psi unit is for auxiliary power while the single-stage 50-psi machine is for fire detection.

Although these small "package" type units have been designed for and found use mainly in aircraft, their advantages in the design of other types of machines remain for the engineer to tap. Units for operation at pressures up to 1500 psi have been produced in quantity and up to 3000 psi experimentally for pneumatic operation of bomb-bay doors, automatic gun turret operation, etc. Their presence today makes possible the consideration of unit pneumatic systems for power or control on a great variety of machines.

Part II of this series will deal with typical system pressures and important factors in selecting an ideal pressure; air receivers, transmission of air, and sealing problems also will be discussed.

Photo, courtesy Harvey Machine Co.

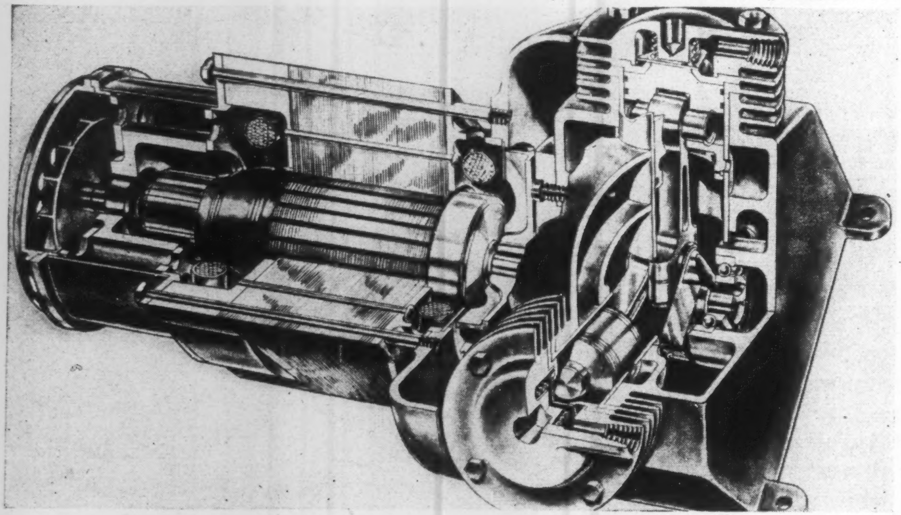
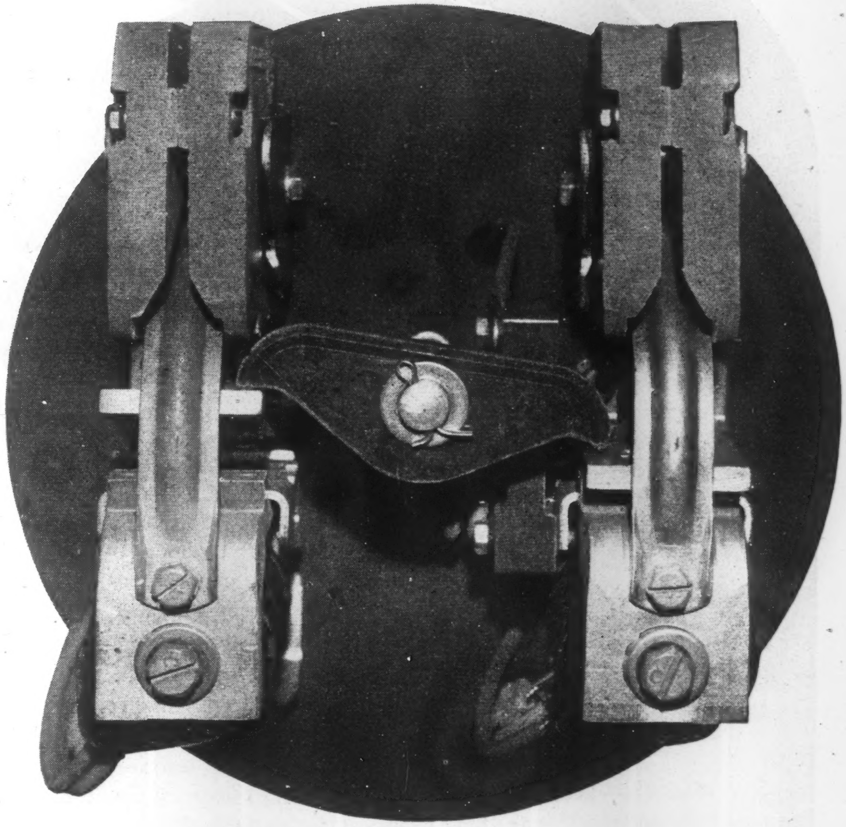


Fig. 8—One-half horsepower, single-stage aircraft compressor for continuous duty at 50 psi weighs but 15 pounds complete



Interlocks

. . . their use in machine controls

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ONE of the outstanding advantages of magnetic controls is the ease with which the devices of an individual controller or the controllers of a multimotor drive may be interlocked. The term "interlock", as used by control engineers, designates mechanical parts or electrical circuit elements designed to prevent, or to cause, certain circuit conditions to exist, either to avoid an undesired control operation or to initiate a desired control operation.

Purpose of Interlocks: Functionally, interlocks are used to perform either one of two fundamental control functions, namely: (1) To prevent faulty operation,

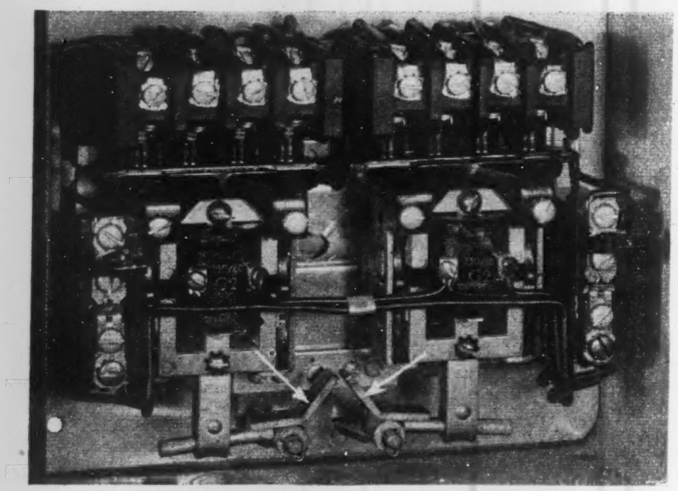


Fig. 1a—Above—Horizontal mechanical interlock between a pair of lift type ac contactors prevents faulty operation of control

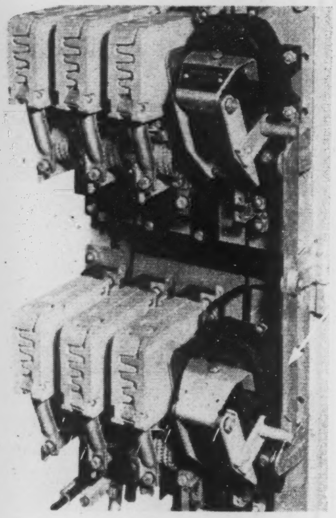


Fig. 1b — Left — Vertical interlock between a pair of shaft type ac contactors

and (2) To initiate an automatic control sequence.

Preventing faulty operation: For instance, when a motor is equipped with a reversing controller, it must be impossible to close the forward and reverse contactors simultaneously otherwise the power lines would be short-circuited. Or, in a multimotor production machine, such as a machine tool, to prevent damage to the tool and the work, the coolant pump motor must be started before the tool may be brought in engagement with the work. The control for an electric furnace must be so arranged that the charging mechanism cannot be actuated unless the charging door has been opened previously. On a planer, traversing of the tool must be impossible unless the table is at rest and the tool is free of the work. This type of interlocking is accomplished by preventing the closing of motor contactors unless other contactors are either open or closed; or limit switches may prevent contactor closing unless a driven member of the machine is in a certain position.

Initiating an automatic control sequence: Considering a single motor controller of such a size that full-voltage starting is not permissible, interlocks cause the accelerating contactors to close without further action on the part of the operator, once the motor has been connected to the line. In equipment involving a multiplicity of individual motorized drives, as with a train of conveyors, for instance, the various motors are so interlocked that when the first motor is started, all will start in sequence.

Classes of Interlocks: The examples cited are a selection of typical problems confronting control equipment designers. To solve these problems, a number of components are available which can be used in the physical layout of the controls and in the design of circuits. These components and their functions are:

1. *Mechanical Interlocks*: Mechanical parts attached to a pair of contactors, so designed that only one of two contactors can be closed at a time, and the closing of the second contactor is prevented by a mechanical lockout action
2. *Electrical Interlocks*: Auxiliary contacts attached to the power contactors, actuated by the contactor magnet, simultaneously with the power contacts
3. *Limit Switches*: Pilot switches mechanically actuated by the driven machine, to indicate the mechanical position of the drive.

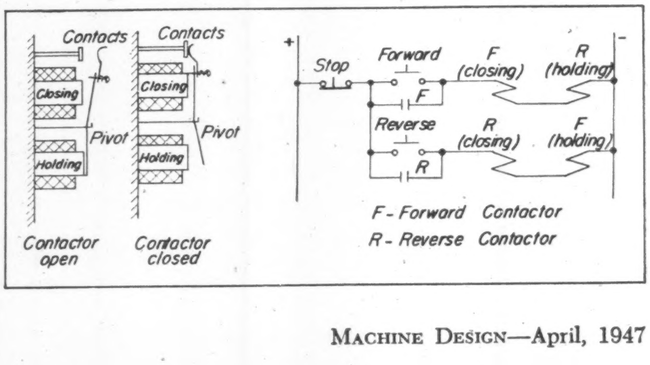
Mechanical Interlocks: The design of mechanical interlocks is largely predicated on the details of construction of the contactors with which they are used. Depending on the physical arrangement by the two contactors of the pair, there are two major types, horizontal and vertical interlocks. Shown in the head illustration and in *Fig.* 1 are several typical designs as used on dc and ac contactors.

Walking Beam Prevents Faulty Operation

The mechanical interlock shown in the head illustration is a walking beam, pivoted on a pin arranged midway between the contactors. When one contactor is closed, its armature tilts the mechanical interlock. When the coil of the second contactor is energized, its armature is held open by the interlock, and the contactor is prevented from closing. Should one contactor stick closed and fail to drop out when its coil is de-energized, the pull on the armature of the second contactor, when its coil is energized, may force the first contactor open.

A pair of small ac contactors of the vertical lift type, mounted side by side is illustrated in *Fig. 1a*. Under each magnet is a lever which is tilted by the upward pull of the magnet armature. The ends of the two levers that face each other are bent and so shaped that when one contactor is closed, the interlock of the second contactor

Fig. 2—Interlocking of dc reversing contactors by holding coils, showing schematic arrangement of contactors and elementary diagram of control circuits



is prevented from tilting and its armature cannot close.

An example of a vertical mechanical interlock is given in *Fig. 1b*. This type of interlock is generally used on larger ac contactors of the shaft type, which are arranged above each other. The interlock consists of a vertical bar, pivoted midway between the contactors. When one contactor is closed, a pin on its armature tilts the interlock, which then interferes with a pin on the armature of the second contactor, preventing it from closing.

For proper functioning of mechanical interlocks it is necessary that the contactors are mounted and lined up correctly. The interlock design must allow for permissible manufacturing tolerances in the parts of a given contactor design. When one contactor is closed, the second one must be prevented positively from closing its tips. On the other hand, the contactor which has first been energized must be able to seal its armature closed without interference from the interlock.

Mechanical interlocks are used principally to prevent simultaneous closing of reversing contactors, which would short-circuit the power system. Another important application is the interlocking of line and dynamic braking contactors on dynamic braking controllers.

Holding Coils Conserve Space

On small dc contactors it is sometimes difficult, if not impossible, to arrange for mechanical interlocks. Equivalent interlocking can be obtained by using contactors with a dual magnet and a combination of closing and holding coils, *Fig. 2*. The holding and closing coils of a pair of reversing contactors are cross connected. The armatures of the contactors are of the broken-back type. If the forward contactor is closed by pressing the forward pushbutton, the forward closing coil and the holding coil of the reverse contactor are energized simultaneously. If the reverse pushbutton is then pressed, the pull of the holding coil of the reverse contactor is stronger than the pull of the closing coil, and the reverse contactor is kept from closing as long as the forward contactor is held in the energized position.

Dual magnets with holding coils obtain interlocking equivalent to mechanical interlocks. However, there is one disadvantage. Should one contactor stick closed and fail to open when its closing coil is de-energized, it would be possible to close the second contactor.

Auxiliary Contacts Provide Interlocking

Electrical Interlocks: As previously stated, electrical interlocks are auxiliary contacts, arranged on a contactor and actuated by the magnet simultaneously with the main power contacts. Shown in *Fig.* 3 are several typical interlocks, the specific design of which is largely governed by the details of the contactor with which they are used.

That shown in *Fig. 3a* is a normally-open interlock, forming part of a dc contactor. The term normally-open (generally abbreviated *no*) designates an interlock which is open when the contactor coil is de-energized and is closed when the contactor coil is energized. Conversely, a normally-closed (*nc*) interlock, *Fig. 3b*, is closed when the contactor is dropped out, and it is open when the contactor is picked up.

On shaft type ac contactors the interlocks are often arranged on the end of the shaft, in line with the main contacts. A typical design is shown in *Fig. 3c*. The stationary contacts are studs in the base and the movable contacts are clamped to the motor shaft. When the contactor closes, the *no* interlocks above the shaft close and the *nc* interlocks below the shaft open. By adjusting the length of the stationary contact studs, the *no* and *nc* interterlocks can be made to overlap or to underlap, which may be of importance on some controllers.

Interlocks on small lift type ac contactors are arranged alongside the main contacts and are actuated by the vertical movement of the contactor magnet through a push rod. *Fig. 3d* is a typical design of a *no* interlock. A similar type of interlock is also used on shaft type contactors, *Fig. 3e*. The interlock assemblies are mounted below

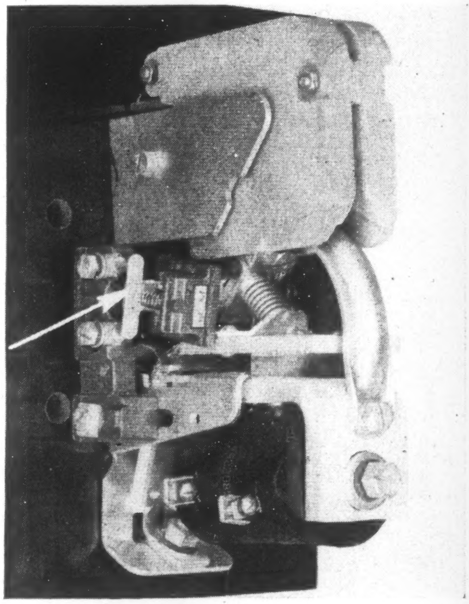


Fig. 3a — Left — Normally-open electrical interlock

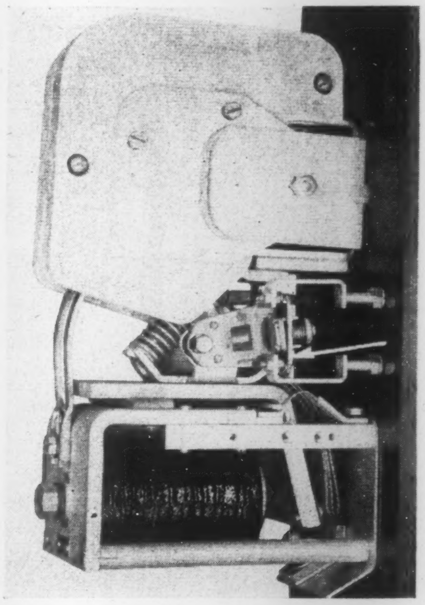


Fig. 3b—Right—Normally-closed electrical interlock

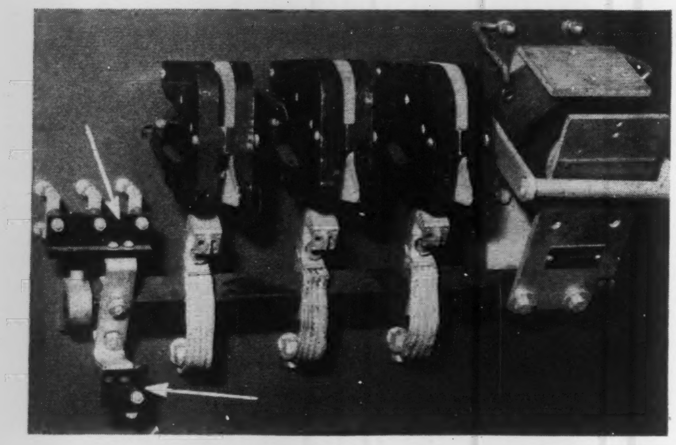


Fig. 3c—Above—Both normally-open and normally-closed electrical interlocks at end of shaft on shaft type contactor

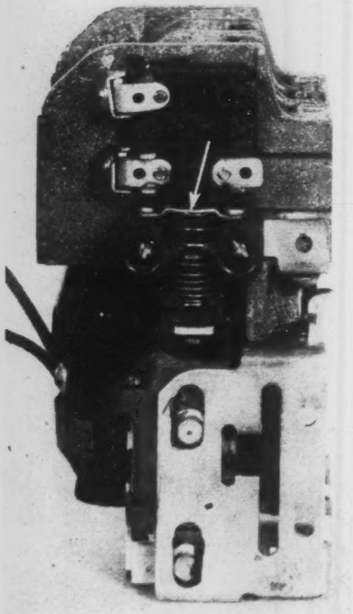
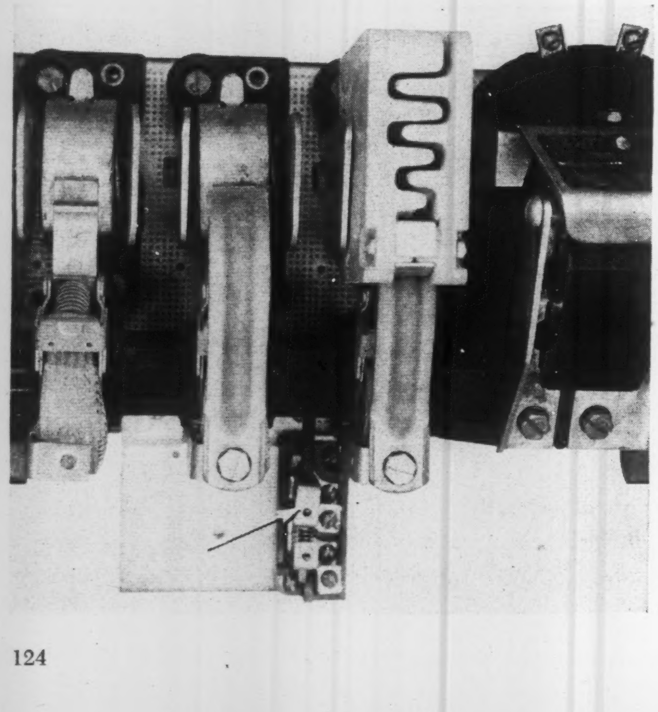


Fig. 3d—Left—Lift type contactor with electrical interlocks alongside main contacts

Fig. 3e—Below—Shaft type contactor with electrical interlocks below shaft



the contactor shaft, and the push rods are actuated by the turning motion of the shaft. *Fig.* 3*f* shows in a schematic manner the working parts of *no* and *nc* interlocks.

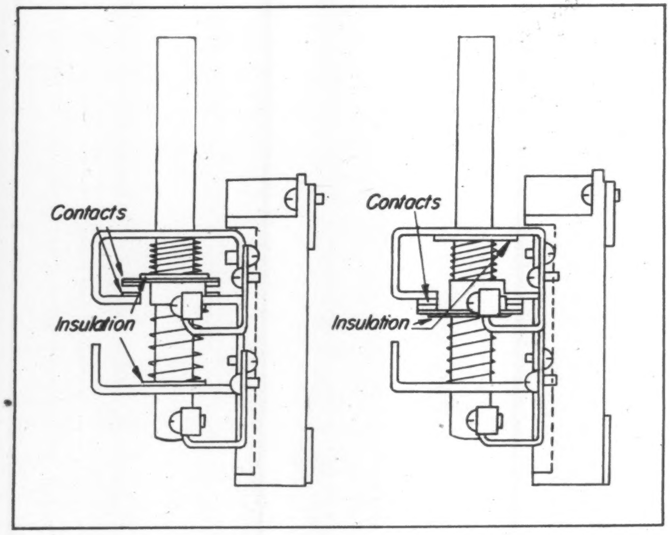
Special time-delay interlocks are available which have a definite time interval between contactor closing and the operation of the interlock contact. Such interlock assemblies involve additional mechanical parts such as escapement mechanisms, dash-pots, inertia disks, and the like. Because such time-delay features involve additional wearing parts, adding to maintenance and reducing life, time-delay interlocks are used only on infrequently operated controllers, and definite time relays with inherently long life are preferred when time-sequencing is required.

Capacity of Electrical Interlocks

No industry standards have been established for the rating of electrical interlocks. Manufacturers' recommendations should be followed in determining the amount of control power which an electrical interlock may handle. To present a general picture of the control power which can be handled on interlocks it may be said that their current carrying capacity is usually between 5 and 15 amperes. The interrupting capacity of dc interlocks is of the order of one ampere or less at 250 volts. On dc controllers, interlocks are used to interrupt contactor coil circuits, but they should not be used to interrupt highly inductive small power circuits such as motor fields or shunt brakes. When a large number of contactor coils are connected to a single interlocking circuit, it may be advisable to connect two interlocks in series to increase their interrupting capacity. Usually, ac interlocks have an interrupting capacity comparable to that to size 00 contactors.

Capacitors as Arc-Supressors: On dc controllers, troubles are sometimes encountered because of excessive arcing on interlock contacts. Such difficulties can be remedied by the use of capacitors of 0.5 or 1 microfarad

Fig.3f—Schematic diagrams of normally-open, left, and normally-closed interlocks



capacity, which act to suppress the arcs. Two circuits which accomplish the desired result are indicated in *Fig.* 4.

In *Fig. 4a* the capacitor is connected in parallel with the interlock contact and in *Fig. 4b* the capacitor is connected in parallel with the contactor coil. Both circuits are equivalent in that the capacitor provides for a path through which the magnetic energy of the contactor coil may discharge. From an operational point of view, *b* is preferred. Should a capacitor failure occur causing the capacitor to be short-circuited, circuit *a* would result in the contactor coil being energized inadvertently. Circuit *b* would result in a short circuit around the contactor coil. This would cause the control circuit fuses to blow, but no faulty contactor closing would occur.

Holding Interlocks: Pushbutton operated controllers represent the type most widely used on production machinery. To explain the fundamental uses of interlocks for general-purpose machinery, driving motors may be considered of such size that full-voltage starters, consisting of a line contactor *M* and an overload relay *OL*, can be used. In the following paragraphs fundamental circuits are discussed. These can be applied to any type of control which contains accelerating or other contactors in addition to the line contactor. In the subsequent circuit diagrams, control circuits only are shown, these can be used in connection with either dc or ac controls.

Provides Undervoltage Protection

Several simple starting circuits are illustrated in *Fig.* 5. The fundamental starting circuit for continuously running drives is shown in *Fig. 5a*. When the start button is pressed, line contactor *M* closes and connects the motor to the line. Simultaneously with the main power contacts, a *no* interlock (also designated as *M*) closes in parallel with the start pushbutton, which can then be released. Contactor *M* "holds" itself closed through its own interlock and stays closed. When the stop button is pressed, or when overload relay *OL* trips and opens its contact, or when control voltage is lost, *M* drops out and the motor is stopped. To restart the motor, the start button must be pressed again. Therefore, controllers operated by momentary contact pushbuttons with holding interlocks inherently provide "undervoltage protection". Standard starters always include a *no* holding interlock to permit use of the starters in conjunction with pushbuttons.

Jog Button Requires a Latch

If a drive is to be run continuously most of the time but may be jogged occasionally, a jog button is added, *Fig. 5b*. When the start button is pressed *M* is energized and holds itself in as in *Fig. 5a*. When a jogging operation is performed, the jog button is pressed and contactor *M* is energized, the motor running as long as the jog button is held depressed. As the back-contact of the jog button is open, the circuit through the holding interlock is open, and *M* drops out when the jog button is released. As a precaution, a latch should be provided on the jog button, preventing the back-contacts from closing should the jog button be released suddenly. This precludes the possibility that the back-contacts of the jog button close before contactor *M* drops out, which would cause the contactor to hold itself in and the drive to keep running inadvertently.

Some drives operate intermittently in definite cycles. A typical example is a rotary car dumper. The motor is started and turns the dumper through a complete revolution, being stopped automatically by a limit switch. A simple circuit to accomplish this sequence is shown in *Fig. 5c*. At the beginning of the cycle, the limit switch is open. To start the motor, the start button is held until the motor has traveled a sufficient distance to cause the limit switch to reclose. When the start button is then released, *M* is held in through the limit switch and the holding interlock. At the end of the cycle, the limit switch opens, *M* drops out, and a new cycle must be initiated by pressing the start button again.

Interlocking of Reversing Contactors: On pushbutton operated dc reversing starters, the contactors need only be mechanically interlocked, and the control circuit is in fact a combination of two simple starting circuits with a common stop button, *Fig. 6a*. Forward contactor *F* and reverse contactor *R* are equipped with holding interlocks, connected in parallel with the forward and reverse pushbuttons, respectively. Supposing the forward pushbutton has been pressed and contactor *F* is closed,

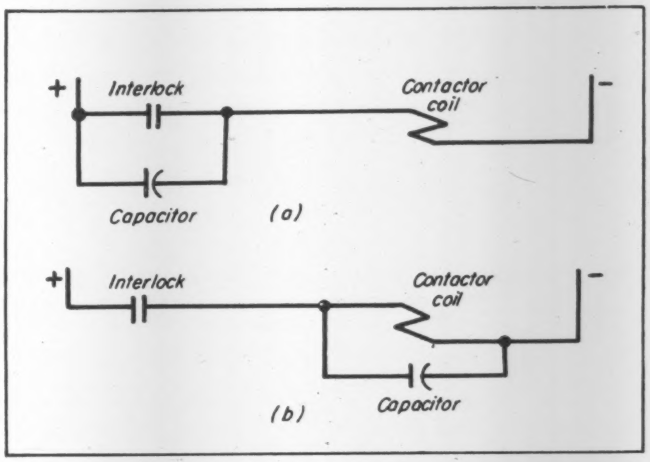
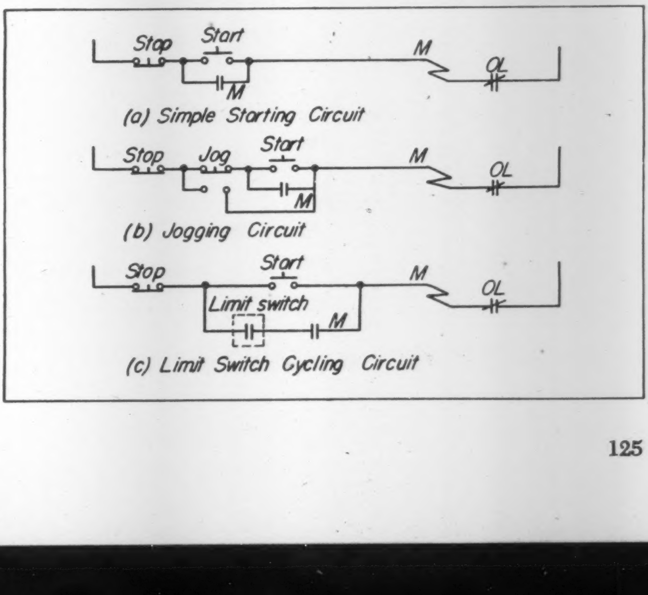


Fig. 4—Capacitors used as arc suppressors on dc controllers, Arrangement shown at (b) is preferred

Fig. 5—Schematic arrangements of starting circuits



then when the reverse button is pressed, the coil of contactor *R* is energized, but *R* is prevented from closing by the mechanical interlock. As the inrush current of dc contactor coils is equal to the holding current, the coil of *R* would not overheat and no harm would be done. If this circuit were used on an ac controller, the high inrush current of the coil of contactor *R* would cause the coil to burn out in a short time.

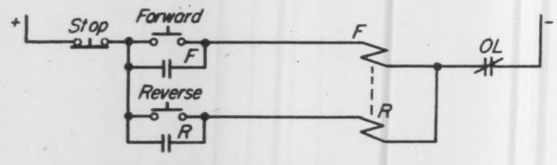
On ac reversing controllers it is necessary to use electrical in addition to mechanical interlocks, so that the coil of a contactor, which is mechanically locked out, cannot be energized. This can be accomplished by cross-interlocking the reversing contactors through *nc* electrical interlocks, *Fig. 6b*. In addition to the *no* holding interlock, each contactor has a *nc* interlock. If forward contactor *F* is closed, its *nc* interlock in series with the coil of reverse contactor *R* is open. When the reverse button is then pressed, nothing happens as the coil of contactor *R* is not energized.

Cross-Interlocking Obviates Contacts

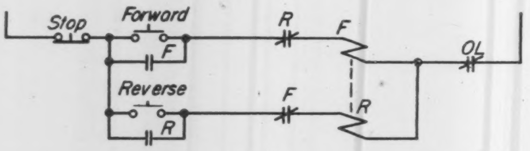
Equivalent results are obtained if the pushbuttons are equipped with *nc* back-contacts. By cross-interlocking the pushbuttons, the *nc* interlocks on the contactors can be eliminated, *Fig. 6c*. For instance, when contactor *F* is closed and the reverse pushbutton is pressed, its back-contact interrupts the coil circuit of contactor *F*, so that *F* drops out and *R* is permitted to close. Likewise, when *R* is closed and the forward button is pressed, *R* drops out and *F* closes.

Fundamental Interlocking Circuits: All multimotor-driven machinery requires a multitude of interlocking circuits. Modern machine tools use a multiplicity of motors, and *Fig. 7* shows a horizontal boring and milling machine as a typical example. The control panel, mounted on the column, contains a number of starters and speed adjusting controllers, all co-ordinated and interlocked to obtain proper sequencing of the various individual motorized drives. The complete diagram of such co-ordinated drives may become rather complicated, and a practically unlimited number of different circuits may be employed, the circuit details depending on the specific requirements of each application.

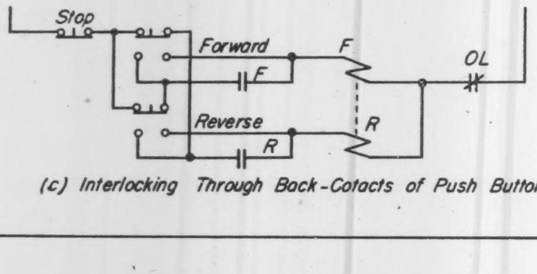
Fig. 6—Schematic diagrams for reversing control circuits



(a) Mechanical Interlocking Only (do not use on AC controllers)



(b) Mechanical and Electrical Interlocks



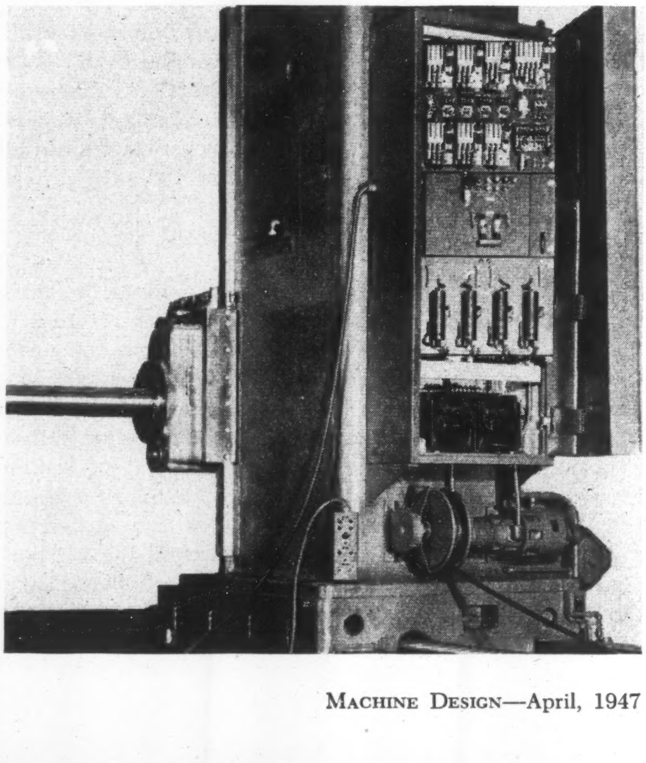
(c) Interlocking Through Back-Cotacts of Push Buttons

The majority of all commonly employed interlocking circuits can be subdivided by requirements into three basic types of circuits incorporating certain fundamental features, regardless of how the circuit details may be worked out on a particular control. These basic interlocking requirements are:

1. A motor must not start unless some other motor has been started first. Example: On a milling machine the coolant pump must be operating before the milling motor can be started
2. Two or several motors must be started with one pushbutton and in proper sequence. Example: On a milling machine the coolant pump and the milling cutter may be started in sequence by a single pushbutton
3. A motor shall not start unless another motor is at rest. Example: On a milling machine any motion perpendicular to the direction of the cut should be prevented unless the tool is at rest.

Shown in *Fig. 8* are basic interlocking circuits designed to satisfy these requirements. To make the diagrams simple and to eliminate details not necessary for understanding the desired interlocking sequence, the diagrams have been drawn for full-voltage starters of two motors. The starter of motor 1 consists of line contactor 1*M* and overload relay 1*OL*, whereas the starter of motor 2 consists of line contactor 2*M* and overload relay 2*OL*.

Fig. 7—Horizontal boring and milling machine panel shows typical mounting of interlocked controls for sequencing



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Interlocks Required for Specific Controls

Item	Control Problem	Interlocks Required
1	To hold in starter after pushbutton has been pressed	Holding interlock, *no*, always provided as part of standard starters
2	To prevent simultaneous closing of dc reversing contactors	Mechanical interlock only between reversing contactors or cross-connected holding coils
3	To prevent simultaneous closing of ac reversing contactors	Mechanical interlock between reversing contactors plus electrical interlocking through *nc* interlocks on contactors or back-contacts on pushbuttons
4	To insure sequence in starting several motors	Standard starters with cascade connection of pushbuttons
5	To start several motors in sequence from one pilot station	Sequence interlock, *no*, added to all starters except last one in sequence
6	To cross-interlock several motors	Interlocks, *nc*, added to starters or limit switches used in series with line contactor coils of other starters

In *Fig.* 8*a*, motors 2 and 1 are so sequenced that motor 2 can only be started when motor 1 is running. As an example, motor 1 may drive a coolant pump and motor 2 a cutting tool. Motor 1 may be started and stopped at any time. However, a feed to starter 2 contactor coil exists only as long as contactor 1*M* is closed. The starting and stopping of motor 2 has no effect on motor 1. However, motor 2 is stopped whenever motor 1 is stopped, either by pressing its stopbutton or by an overload.

An important advantage of this circuit is that it uses standard pushbuttons and standard full-voltage starters which are equipped with holding interlocks. Standard three-wire connections are used between starters and pushbuttons. The only special connection is that the stop button of motor 2 is connected to the interlock terminal of starter 1 instead of the line terminal of starter 2.

In *Fig.* 8*b* is shown a circuit which requires only a single pushbutton station to start first motor 1 and then motor 2. As an example, motor 1 may again drive a coolant pump and motor 2 a cutting tool. The circuit arrangement is somewhat less flexible, as both motors are always started together, but where individual operation of motor 1 is not necessary, this circuit offers the saving of one pushbutton station. An overload on motor 2 shuts down motor 2 only. An overload on motor 1 shuts down both motors.

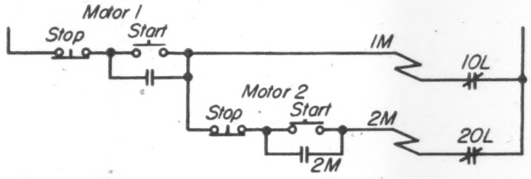
It is no longer possible to use a standard starter for motor 1, because an additional *no* interlock (in addition to the standard holding interlock) is necessary. It may be asked, whether the second interlock on 1*M* could not be omitted. Both motors would still be started from a common pushbutton station. However, an important interlocking feature would be lost. By holding the start button pressed, it would be possible to start motor 2 without starting motor 1, for instance in case of coil 1*M* being burned out or overload relay 1*OL* being tripped open.

Requires Special Starters

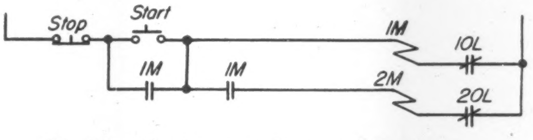
Cross interlocking of two motors is indicated in *Fig.* 8*c*. The circuits are so arranged that motor 1 can only be started when motor 2 is at rest, and vice versa. An *nc* interlock on 1*M* is connected in series with 2*M* coil, and an *nc* interlock on 2*M* is connected in series with 1*M* coil. This method of interlocking is similar to the previously described interlocking of reversing contactors. Cross interlocking requires special starters having one *nc* interlock in addition to the holding interlock.

If the *nc* interlock were omitted from one starter, for instance 2*M*, the requirement would still be met that both

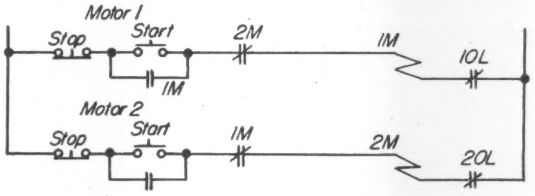
Fig. 8—Basic interlocking circuits



(a) Sequence Interlocking of Two Starters

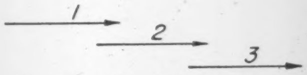


(b) Automatic Sequence Starting of Two Motors

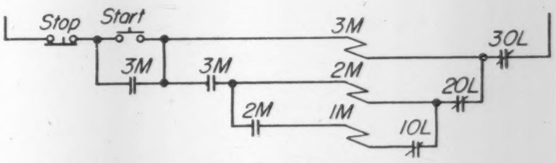


(c) Cross Interlocking of Two Starters

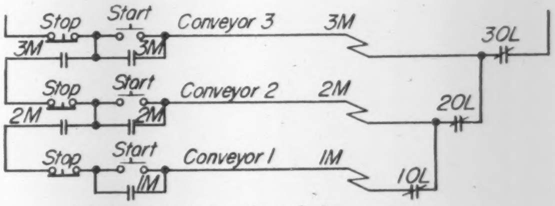
Fig. 9—Control of conveyor sequence



(a) Schematic Conveyor Sequence



(b) Automatic Starting of Train



(c) Individual Starting of Conveyors

motors cannot run at the same time. As long as motor 1 runs, the *nc* interlock on *1M* prevents motor 2 from being started. If motor 2 is running and motor 1 were then started, the *nc* interlock on *1M* would stop motor 2. Thus, the use of a *nc* interlock on one starter only would permit the associated motor to be started at any time, but the second motor is stopped whenever the start button of the first motor is pressed.

On some equipment it is desired to prevent one drive from starting unless the other drive is in a definite position. The circuit of *Fig.* 8*c* could then still be used, but *nc* interlocks *1M* and *2M* would be replaced by limit switches, mechanically actuated by motors 1 and 2, respectively.

SEQUENCE CONTROL OF CONVEYOR TRAIN: As a typical example of a co-ordinated multimotor drive in which the various motors are interlocked to operate as a unit or as a group in definite sequence, a train of conveyors may be considered. The fundamental control circuit of a conveyor train, consisting of three conveyors, are indicated in *Fig.* 9. *Fig.* 9*a* shows in a schematic manner the sequence of the three units. Conveyor 1 receives the material and delivers it to conveyor 2 which in turn delivers to conveyor 3. The basic requirement for the design of the control system is that no conveyor shall run unless the ones receiving material from it are running, to avoid piling of material on a standing conveyor.

Sequence Interlock for Conveyors

One method of operating the train is to control all conveyors from a single pushbutton station so that the whole train is treated as a unit. *Fig.* 9*b* is an elementary diagram of the basic control circuits. Each motor is equipped with its starter consisting of line contactor and overload relay. When the start button is pressed, conveyor 3 starts first. An *nc* sequence interlock on *3M* starts conveyor 2, and an *no* sequence interlock on *2M* starts conveyor 1. Standard starters can be used for conveyors 1 and 2. The starter for conveyor 3 must be equipped with an extra *no* sequence interlock to prevent running conveyor 2 by holding down the start button, should a burned-out coil on *3M* keep conveyor 3 from starting.

On long conveyors which are driven by larger motors, it may be desirable to introduce a time interval between the starting of the several conveyors making up the train. For such systems, special controls would be required anyway, and the time interval could be obtained by making the sequence interlocks of the time closing type.

Cascading of Contacts Provides Protection

The overload relay contacts in *Fig.* 9 are cascaded so that in case of an overload on one conveyor, all conveyors feeding material to it will be stopped whereas all conveyors receiving material from it will continue to run. When small motors are involved, the line contactors drop out fast and the cascading of the overload relay contacts is of no practical importance. The same operating results would be obtained if all relay contacts were connected to one side of the line. However, when large motors are involved and when time-delay closing sequence interlocks are used, the delay in stopping conveyors in sequence may become very undesirable, and the cascading of the relay contacts will then insure that all conveyors feeding the overloaded one will be stopped immediately.

On some conveyor installations, especially those involving long trains, material may be received from a number of loading stations along the line. It would then be unnecessary to run the whole train all the time and the operator would prefer to have control over the number of conveyors he desires to run. This requires that each conveyor is started by its own individual pushbutton station and sequence interlocks must be included in the starters to insure that no conveyor can be started unless the ones receiving load from it are running. *Fig.* 9*c* shows the elementary control circuits of such a system. The stop buttons are cascaded, so that when one conveyor is stopped, all other conveyors feeding it are stopped simultaneously.

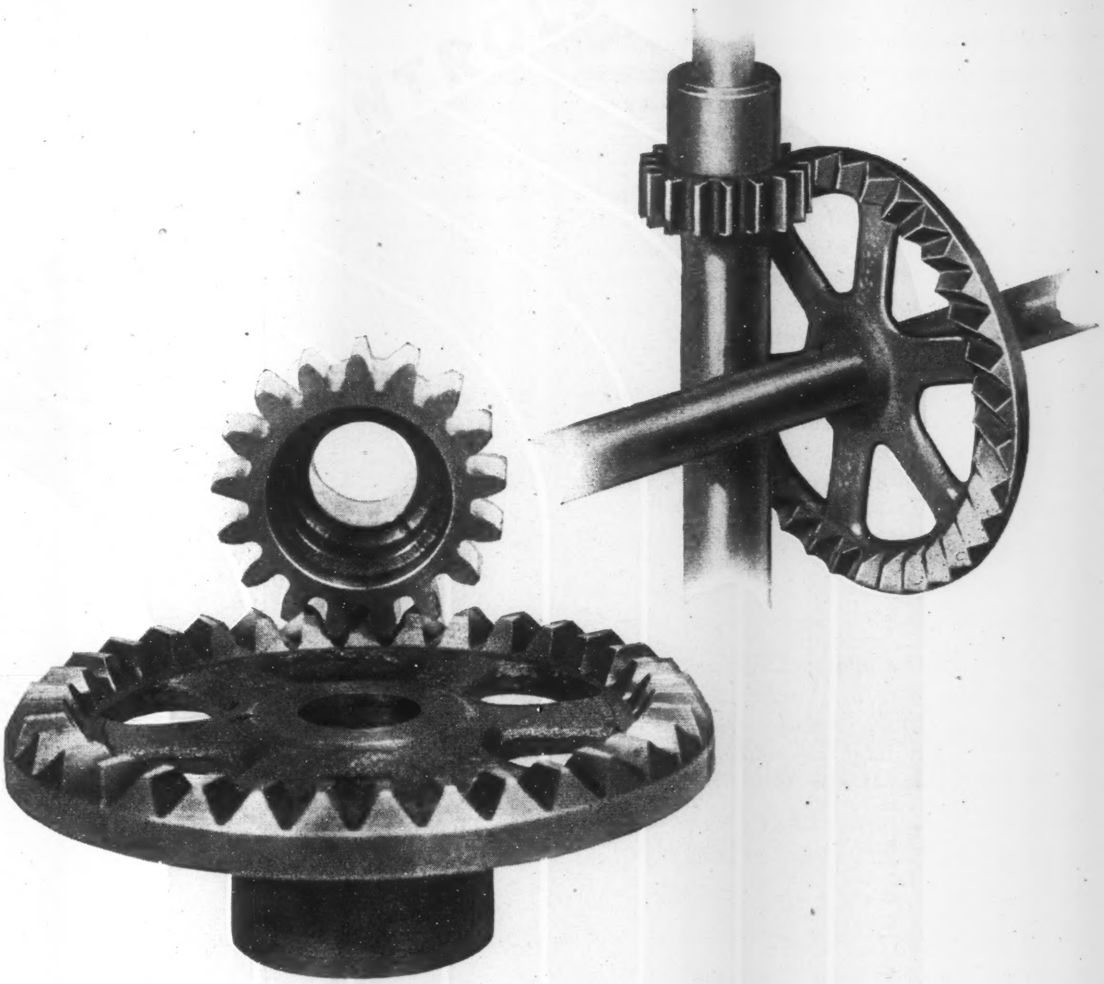
While the sketches of *Fig.* 9 show a system consisting of three drives, any number of sequenced drives can be controlled in the manner indicated by simply adding further starters to the train.

General Considerations

Interlocking requirements of industrial controllers are so numerous and varied that it is impossible to describe all possible interlocking combinations in one article. The control designer must study each control problem individually to ascertain the best circuit combination for his particular application. Several general considerations, when observed in choosing the interlocking system for a given combination of drives, will greatly help in arriving at a satisfactory circuit layout:

1. Arrange control circuits in as simple and straightforward a manner as possible. Assign one, and only one, control function to each interlock used. "Trick" circuits, imposing multiple duties on interlocks for the purpose of saving an interlock or two, are likely to cause more trouble than the saving in cost is worth
2. It is preferable to arrange all interlocks and pilot devices on one side of the control circuit and connect one side of the coils solidly, or at least through a straight series contact sequence, to the other side of the line. This minimizes the possibility of "sneak" circuits. On dc systems one line (usually the negative one) is generally grounded. On dc controllers, coils should be connected to the grounded line and pilot devices and interlocks to the ungrounded line. A ground in one of the control circuits will then result in a short circuit causing the fuses in the control lines to blow, but avoiding the possibility of energizing a contactor coil and starting a motor inadvertently
3. Scrutinize the sequence of interlocking devices carefully and ascertain that failure of a device will result in a shutdown rather than in an inadvertent start, which might endanger the operating personnel. This "fail-safe" feature should be given prime consideration even if its realization might result in a somewhat increased expense.

The accompanying tabulation presents a brief summary of the interlocking problems and the required interlocks as discussed in this article.



Designing Face Gears

How to calculate principal dimensions and determine the nature of the contact between a face gear and its mating involute pinion

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FACE gears may be defined as gears whose teeth lie in a plane normal to the axis of the gear, and which will mesh with involute gears having cylindrical base circles, with the axes at 90 degrees to each other. When the axes of a face gear and pinion intersect, the face gear is called an "on-center" face gear; when the axes do not intersect, it is called an "off-set" face gear. An on-center face gear and mating spur pinion are shown in the lead illustration at the left, while an off-set face gear and its mate are shown at the right.

It will be seen that a displacement of the pinion along its axis does not affect the operation of the two gears. As will be shown later, the pitch point on the pinion varies from the inside diameter to the outside diameter of the face gear; that is, the face gear has a variable pressure angle, but nevertheless meshes with a pinion having a constant base circle.

To understand the action of the face gear and pinion, it will help to picture, in place of the gears, a pair of imaginary friction rolls of narrow width, having diameters equal to the pitch diameters of the gear and pinion, which transmit uniform motion from one shaft to another at the same speed ratio as the gears in question. The action of an on-center face gear and pinion, shown diagrammatically by the friction rolls in *Fig.* 1, will be considered first. Let N_p and N_f equal the numbers of teeth in the pinion and face gear, respectively, ω_p and ω_f equal the respective angular velocities, and K equal the speed ratio such that

$$K=\frac{N_p}{N_f}=\frac{\omega_f}{\omega_p} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

If r_1 and R_1 equal the active pitch radii of the face gear and pinion, then the corresponding tangential velocity is $r_1\omega_p$ and $R_1\omega_f$. These tangential velocities are drawn perpendicular to the radii connecting the point of contact P with the center of each gear. It will readily be seen that

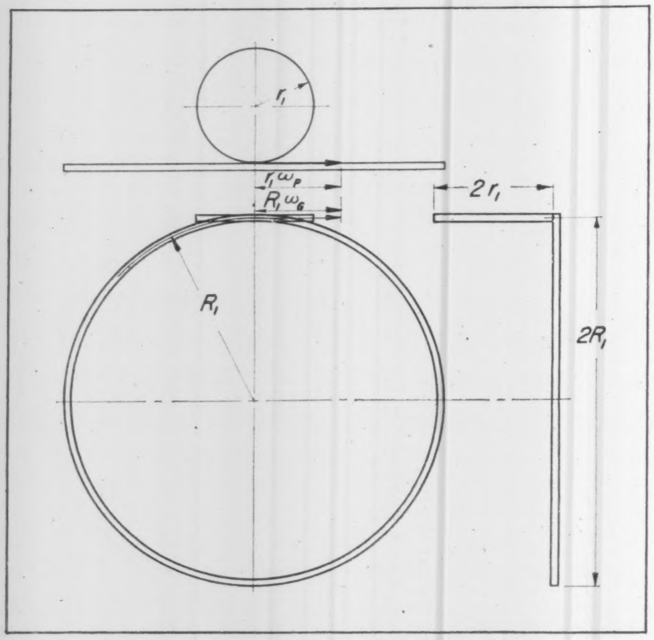
$$r_1\omega_p=R_1\omega_f$$

Therefore,

$$\frac{r_1}{R_1}=\frac{\omega_f}{\omega_p} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\frac{r_1}{R_1}=K$$

Fig. 1—Below—Friction rolls illustrate diagrammatically the action of an on-center face gear and its mating pinion



If other rings are now established and the number of rings is continually increased, it will be possible to define the pitch surfaces of the face gear and pinion. *Fig.* 2 shows several rings mounted on the axes of the pinion and face gear. The diameters of these rings must all satisfy Equation 2. All contacts occur on line OP_4, and this line must define the pitch surfaces both of the face gear and pinion. As this line revolves about the axis of the pinion, it describes the pitch surface of the pinion. As it revolves about the axis of the face gear, it describes its pitch surface. It readily can be seen that these pitch surfaces are really pitch cones, with the apex on the axis of the face gear. The tangent of the cone angle is K, and once a point is established on the face gear, the corresponding pitch point on the pinion can be ascertained from this relationship.

Since the base circle of the pinion is constant for its entire face width (that is, a base cylinder), the pressure angle of the face gear must increase as the pitch point moves from the inside to the outside diameter. If it is desired to determine the pressure angle of the face gear at any radius R, find the corresponding pitch radius r of the pinion from Equation 2. Then

$$\cos B=\frac{a}{r} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where B is the pressure angle and a is the base radius.

A face gear may be considered as a rack of infinitesimal face width which is wrapped around a circle in the pitch plane of the rack. By developing the circle with radius R_1 in *Fig.* 1, the developed shape of the tooth at that radius becomes that of a rack with pressure angle B_1, such that

$$\cos B_1=\frac{a}{r_1}$$

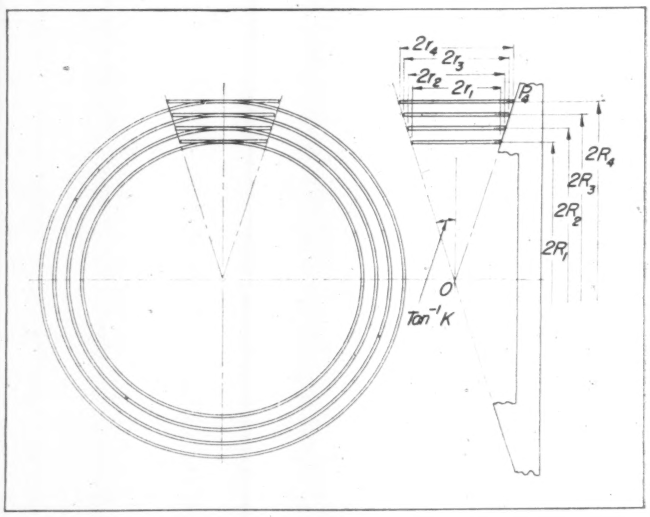


Fig. 2—Above—Diagrammatic definition of gear and pinion pitch surfaces is obtained by drawing a number of disks to represent pinion, with all contacts between large and small disks occurring on line OP_4

The developed shape at R_2 would be a rack with pressure angle B_2, such that

$$\cos B_2 = \frac{a}{r_2}$$

and so on.

The developed shape of the face gear at the inside and outside diameters of the gear is shown in *Fig.* 3. The top view shows the tooth space of the pinion on the line of centers. B_i and B_t represent the pressure angles at the inside and outside diameters and the lines of action for these two pressure angles are shown. Knowing that, in involute gearing, action must take place along the line of action, the rack teeth of the proper pressure angles are constructed tangent to the sides of the pinion tooth space. In a similar manner, the developed shape of the face gear may be determined for any given radius R of the face gear.

To determine the diameter at which the face gear tooth becomes pointed, establish the working depth, which is measured from the outside radius of the pinion toward the center on the line of centers. From this point lines are drawn tangent to the involutes of the pinion teeth. These lines are normal to the pressure angle at the diameter at which the face gear is pointed. Determine r_t from the layout, then find R_t from Equation 2. In most cases, this diameter represents the maximum practical outside diameter of the face gear.

If the pitch radius of the pinion is taken equal to the base radius, a condition known as zero pressure angle obtains. The diameter on the face gear corresponding to this pitch radius is found from Equation 2 by substituting $r_1 = a$. Thus,

$$R_0 = \frac{a}{K} \qquad (4)$$

Since no involute action can possibly take place at a pressure angle less than zero, R_0 represents the theoretical minimum inside diameter of the face gear.

It now will be ascertained if there are any other considerations which prevent the use of the face gear down to R_0. In order to do this, the method of generating a face gear must be considered. This is also shown diagrammatically in *Fig.* 3. A cutter is employed of the same base circle, number of teeth, outside diameter, and tooth thickness as the mating pinion, with allowance being made only for clearance in the root of the face gear space and for backlash. The relative position of the cutter axis and the face gear axis is exactly the same as that of the pinion axis and the face-gear axis. The cutter is reciprocated along, and rotated about its axis. The face gear blank rotates at the same time about its axis at a uniform angular velocity, the speed ratio between cutter and face gear being K. The cutter teeth are relieved to prevent rubbing.

It will be seen that this method of generating a face gear will provide tooth profiles which are conjugates to

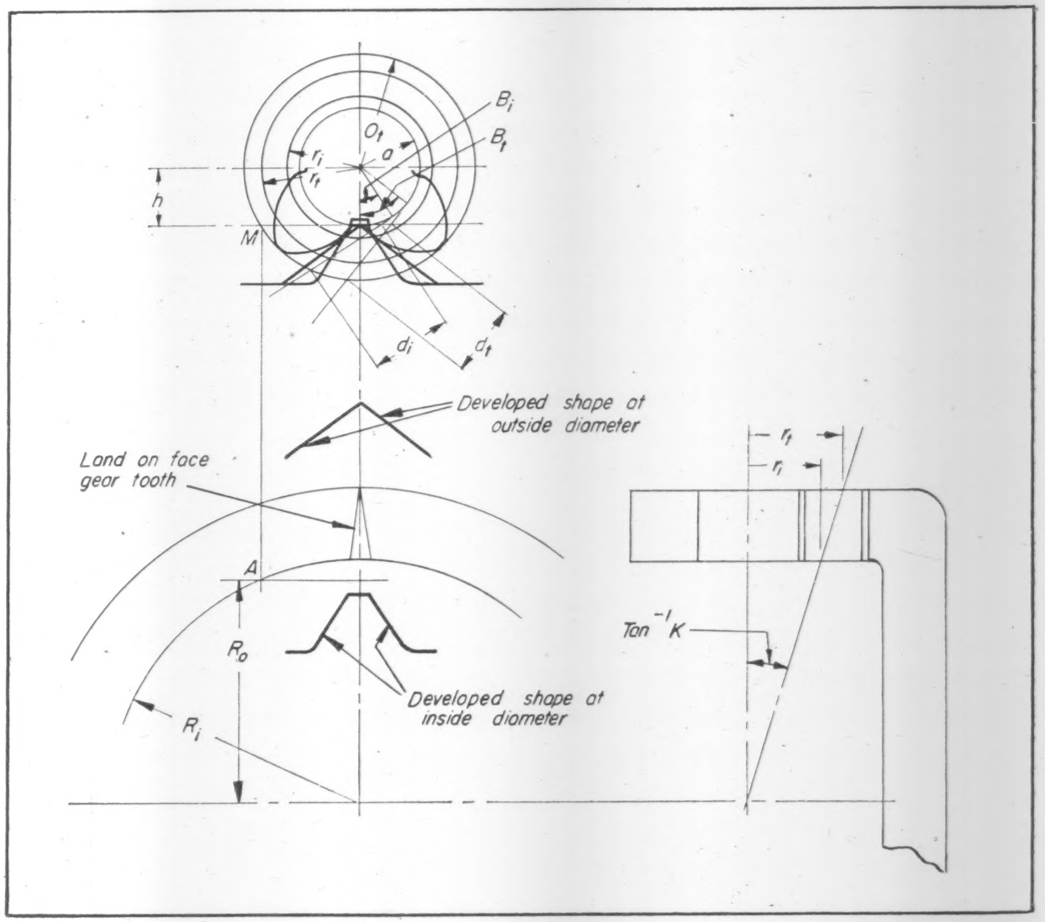


Fig. 3—Developed shape of on-center face-gear teeth at inside and outside diameter of gear, showing how land of each tooth comes to point at the gear periphery

the involute profiles of the cutter teeth. However, there is a danger that the cutter, as it starts to cut the face gear at A, will remove stock which should be part of the conjugate profile. In actual practice, it will be found that that portion of the tooth lying inside R_i in *Fig.* 3 will be trimmed away and will, therefore, be useless as far as contact with the mating pinion is concerned. This radius is determined by drawing a perpendicular to the line of centers at distance R_0 from the center of the face gear. The intersection of this perpendicular with a line drawn parallel to the line of centers from M represents the point at which trimming starts. If h equals the outside radius of the pinion minus the working depth, and r_t is the outside radius of the pinion, then

$$R_i = \sqrt{R_0^2 + O_i^2 - h^2} \quad \text{.......... (5)}$$

Usually, R_i is considered to be the minimum effective inside radius of the face gear. The pressure angle at R_i, denoted by B_i, is found as follows:

$$\left.\begin{aligned} r_i &= R_i K \\ \cos B_i &= \frac{a}{r_i} \end{aligned}\right\} \quad \text{.......... (6)}$$

After determining the minimum practical inside diameter and the maximum practical outside diameter of an on-center face gear, the designer must decide what portion of this face width he will use. In doing this he must bear in mind that the lower pressure angles of the face gear, that is, the portion near the inside diameter, are the most effective for transmitting torque, since they provide the greatest amount of involute action with the mating pinion. In *Fig.* 3, d_i and d_t represent the length of the line of action at the inside and outside diameters, respectively. If m_i and m_t represent the contact ratio for involute action at the inside and outside diameters, then

$$\left.\begin{aligned} m_i &= \frac{d_i}{\dfrac{2\pi a}{n_p}} = \frac{n_p d_i}{2\pi a} \\ m_t &= \frac{n_p d_t}{2\pi a} \end{aligned}\right\} \quad \text{.......... (7)}$$

When $m_i = 1$, there is exactly 100 per cent involute action. This is true when

$$d_i = \frac{2\pi a}{n_p}$$

To find the pressure angle B_e at which there is exactly

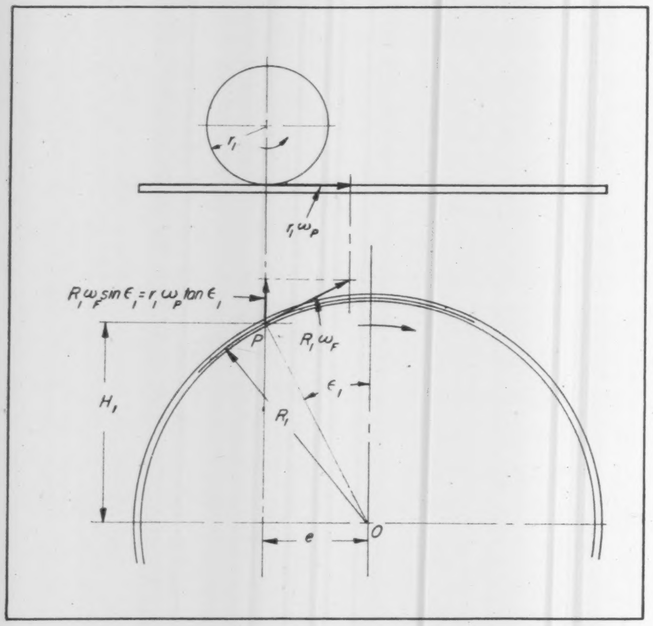
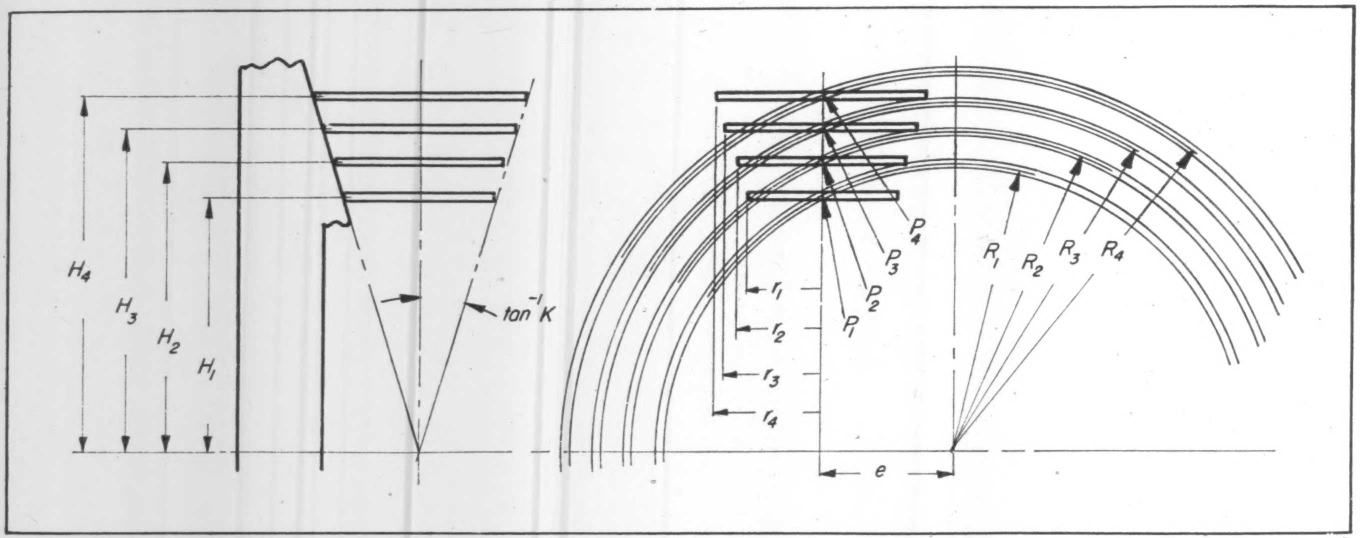


Fig. 4—Above—Friction rolls illustrate diagrammatically the action of an offset face gear and its mating pinion

Fig. 5—Below—As with an on-center face gear and pinion (Fig. 2), offset gear and pinion pitch surfaces are defined diagrammatically by drawing in number of appropriate disks to represent the pinion



100 per cent involute action, refer again to *Fig.* 3. Let q equal the total length of the line of action from the base circle to the outside radius. Then

$$\left.\begin{aligned} q&=\sqrt{r_t^2-a^2} \\ m&=q-d_i=q-\frac{2\pi a}{n_p} \\ b&=\sqrt{a^2+m^2} \\ \cos A&=\frac{a}{b} \\ \cos C&=\frac{h}{b} \\ B_c&=A+C \end{aligned}\right\} \qquad (8)$$

Investigating now the offset face gear and spur pinion, the method of approach is the same as in the case of the on-center combination. Two narrow friction rolls are substituted for the face gear and pinion, as shown in *Fig.* 4. Here, the tangential velocities are $r_1\omega_p$ and $R_1\omega_f$. The directions of $r_1\omega_p$ and $R_1\omega_f$ are different, which was not the case with the on-center face gear, and since uniform motion must be transmitted from one roll to the other, the velocity components in the direction of roll must be equal:

$$r_1\omega_p=R_1\omega_f\cos\epsilon_1 \qquad (9)$$

The slippage, or sliding, S, parallel to the pinion axis is

$$S=R_1\omega_f\sin\epsilon_1 \qquad (10)$$

Since $K = \omega_f/\omega_p$, then by substitution in Equation 9,

$$r_1=KR_1\cos\epsilon_1 \qquad (11)$$

The angle ϵ_1 is the angle of offset for point P. If H_1 is designated as the distance along the pinion axis from P to a plane containing the axis of the face gear and parallel to the diametral plane of the pinion, then

$$H_1=R_1\cos\epsilon_1 \qquad (12)$$

$$r_1=KH_1 \qquad (13)$$

As before, a series of rolls is substituted, *Fig.* 5. The diameters must all satisfy Equation 13, and the contact points P_1, P_2, P_3, P_4 form the boundary of the face gear. These contact points lie on a line which forms an angle, whose tangent is K, with the axis of the pinion. As this line revolves about the pinion axis, it generates the pinion pitch surface, which is a cone. As it revolves about the face gear axis, it generates the face gear pitch surface, which is a hyperboloid of revolution. It can be seen that as e and ϵ approach zero, the face gear pitch surface approaches a cone, as in the analysis of on-center face gears.

The shape of the face gear tooth at any point P is determined, as before, by the active pressure angle at P. If the pitch radius of the pinion at P_1 is r_1, then

$$\cos B_1=\frac{a_1}{r_1}$$

as before. If r_1 is substituted from Equation 13, then

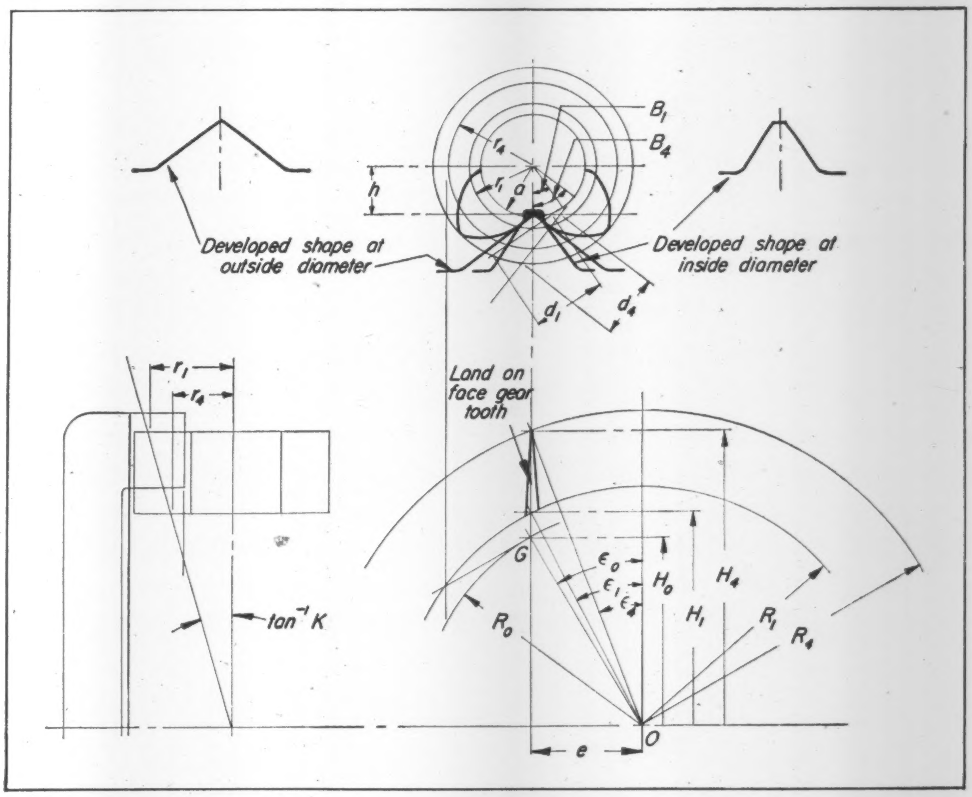

B₁
B₄
r₄
r₁
a
h
Developed shape at outside diameter
Developed shape at inside diameter
d₁
d₄
r₁
r₄
Land on face gear tooth
G
ε₀
ε₁
ε₄
H₀
H₁
H₄
R₀
R₁
R₄
tan⁻¹ K
e
O

Fig. 6—Layout for determining shape of offset face-gear teeth, showing developed shape at inside and outside diameter of gear

$$\cos B_1 = \frac{a_1}{KH_1} \qquad \ldots\ldots (14)$$

Thus, a means is provided for constructing the shape of the face gear tooth at H_1 in a plane normal to the pinion axis. This is shown in *Fig.* 6 where the centerline of the pinion space is shown on the axis of the pinion at offset *e*. The method of construction is exactly the same as in the on-center combination, if H is substituted for the corresponding value of R in the on-center face gear. By finding the pressure angle at which the face gear becomes pointed from *Fig.* 6, the pitch radius for this pressure angle can be determined from Equation 3 and the corresponding H and R from Equations 13 and 12. It is evident that

$$\left.\begin{aligned} \cos \epsilon_1 &= \frac{H_1}{R_1} \\ \tan \epsilon_1 &= \frac{e}{H_1} \\ \sin \epsilon_1 &= \frac{e}{R_1} \end{aligned}\right\} \qquad \ldots\ldots (15)$$

When $r_1 = a$, a condition of zero pressure angle again obtains. Calling the corresponding values of the face gear H_o and R_o,

$$\left.\begin{aligned} H_0 &= \frac{a}{K} \\ R_0 &= \sqrt{H_0^2 + e^2} \end{aligned}\right\} \qquad \ldots\ldots (16)$$

The theoretical minimum values of the face gear are represented by R_o and H_o, since zero pressure angle is the theoretical minimum pressure angle. Actually, due to trimming (similar to the on-center case) the minimum inside diameter must be increased beyond R_o. In order to determine the diameter at which trimming starts, refer again to *Fig.* 6.

Lay out distance H_o along the axis of the pinion, starting at the intersection of the axis with the centerline of the face gear (at offset *e*). Draw a line perpendicular to *OG*. Then find the intersection of this line with a line drawn parallel to the axis of the pinion from the point of intersection of *h* with the outside radius of the pinion. This will give the radius, R_1, on the face gear at which trimming will start and represents the minimum practical inside radius of the face gear. This value can be determined algebraically as follows:

Let L = outside radius of pinion
h = root radius of pinion
ϵ_o = angular offset at H_o
R_1 = inside radius of face gear.

Then

$$R_1 = \sqrt{(L^2 - h^2)\sec^2\epsilon_0 + (e^2 + H_0^2)}$$

To find the amount of involute action at any point on the face gear, first determine the pressure angle at that point from Equation 15 and then use Equation 7 to find the involute action. Equation 8 may be used to find the pressure angle at which there is exactly 100 per cent action.

These then, are the rules for determining the minimum practical inside diameter, the maximum practical outside diameter, the tooth shape at any point, and the amount of involute action at any point. The designer should use the portion of the face gear nearest the minimum inside diameter, since this portion gives the best running conditions with the mating pinion, due to the greater amount of involute action.

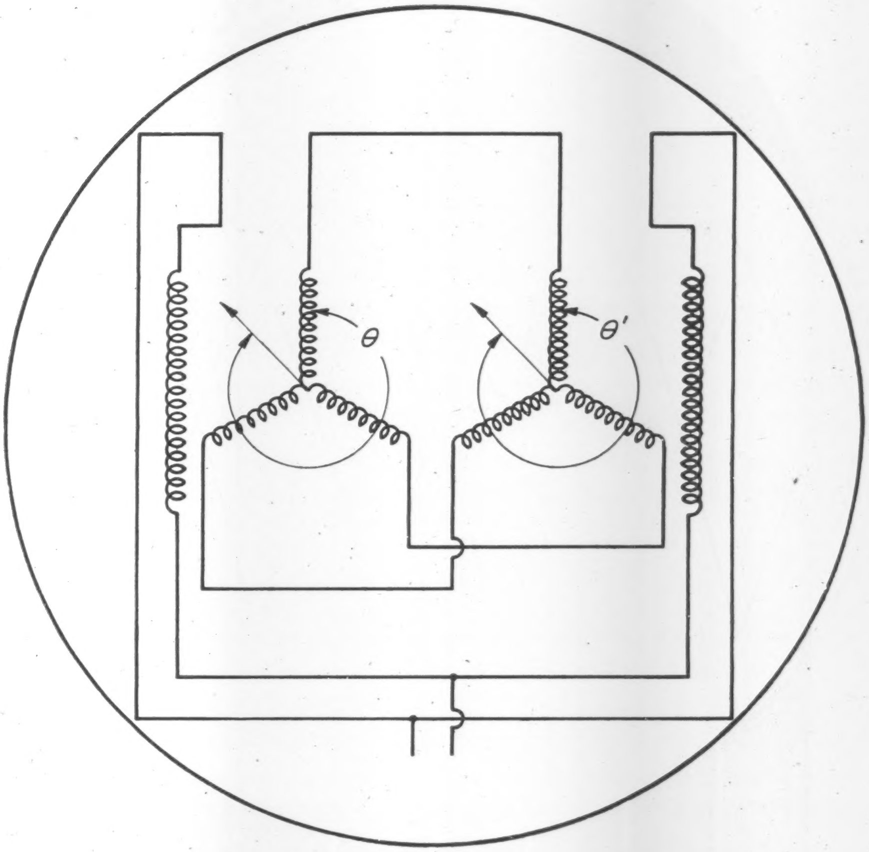
The author is indebted to Dr. A. Zahorski for the development of many of the formulas presented in this article.

Cams Seldom Meet Specifications

IN the course of experimental work on valve gears it has been forcibly brought out that if optimum results are to be obtained, increased accuracy must be attained in the manufacturing of cams. It is slow, tedious, and relatively inaccurate to determine velocity and accelerations of the actual cam from measurements of lift per degree. This is seldom carried out in its entirety, inasmuch as many hours may be spent in comparing test data with a theoretical or drawing diagram, only to find that a slight inaccuracy makes the analysis practically worthless.

To make such studies worthwhile by working with actual and not theoretical diagrams, the true cam profile can be rapidly checked by simply taking an acceleration and velocity reading with an oscillograph having a carefully calibrated pick-up, and the check made under conditions that reduce to a minimum the possibility of depicting motion other than that resulting from the cam profile. This is accomplished by operating at low speed and with minimum parts between the pick-up and the cam, thus eliminating the effect of deflections which are inherent in equipment having numerous parts.

The value of this instrument can be best measured by citing a typical example. In a certain application excessive loading was suspected and a cam designed to reduce the rate of load application. Before testing in the engine, checks were made on the fixture with the result that predictions could be made as to the final result. The design called for a gradual application of load which would result from a curved acceleration diagram, but the actual acceleration was rather abrupt, from which it was suspected that the motion would not be as smooth as desired. When tested in the engine this proved to be true, as early failures occurred, although the error was not of large magnitude. To obtain maximum performance, more accuracy and means of commercially measuring for accuracy will be required, and if optimum results are to be obtained with any given design, proper attention must be paid to seemingly unimportant details.—*From a paper by Vincent C. Young, Wilcox-Rich Division, Eaton Manufacturing Company, presented at the recent annual meeting of SAE in Detroit.*



Modern Synchros

. . . their application to remote control, remote indication and automatic computation

By John L. Everett
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IN MANY modern machines successful co-ordination of remote elements is of paramount importance. Accurate information relating to angles, position and other quantities must be relayed from machine element to machine element in a fraction of a second. With control mechanisms where this was necessary during the recent war, the requirement was met in many cases by the use of synchronous units, sometimes called synchros or selsyns. Devices such as those illustrated in *Fig.* 1 controlled antiaircraft batteries, pointed battleship turrets, piloted B-29's during bombing runs and positioned radar antennas. In many cases extreme accuracy was needed in the

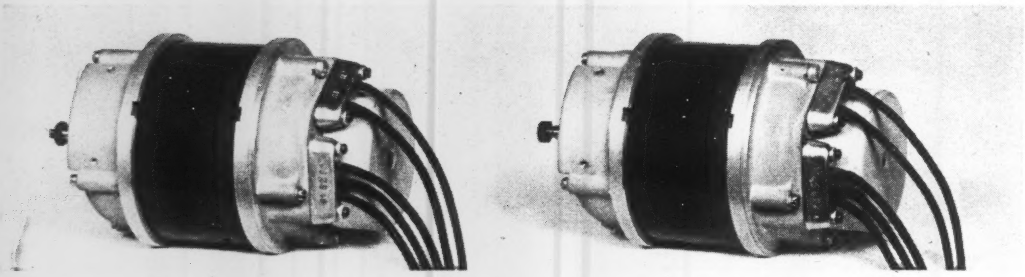


Fig. 1—Instrument selsyns of type manufactured by General Electric. Three wires running from bottom of selsyns are signal leads. Top pair of wires supplies exciting current

transmission of the information; anti-aircraft guns, for example, have to be positioned to a tolerance as small as 0.02-degree. Synchronous units met these accuracy requirements and their speed of response and characteristic durability were not lost in doing so.

Synchros are divided into two main classes; instrument and power. Both are identical in principles of operation but in the former class extreme accuracy is the paramount design consideration, while in the latter, *Fig.* 2, the accent is on high-power output. The use of servomechanisms controlled by instrument synchros, however, makes possible the large-power output of the second type without losing the high accuracy of the first. Because of their much wider utility the discussion which follows will be concerned primarily with the instrument class of synchro. It should be borne in mind, however, that the corresponding power types operate in identical physical fashion.

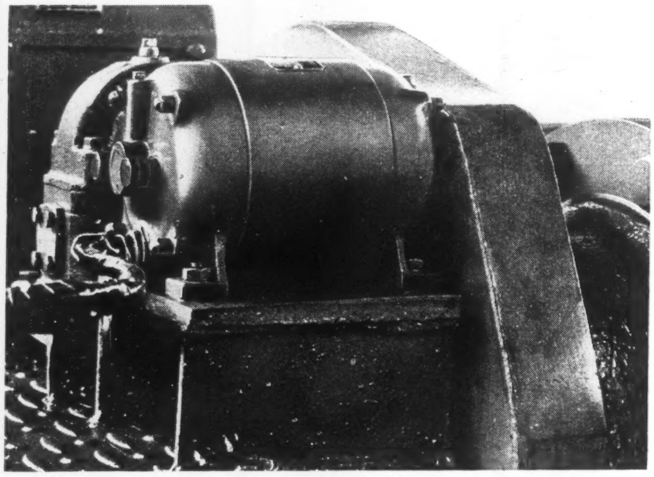


Fig. 2—Above—Position of screw-down on steel-mill rolls is indicated by power-type selsyns

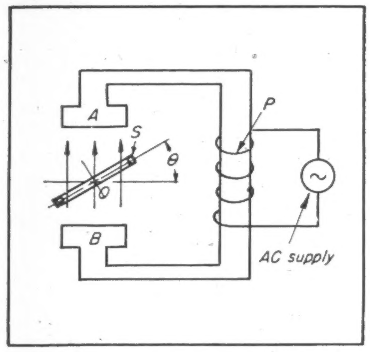


Fig. 3—Right—Transfer of mechanical signal to electrical one in basic synchro. θ represents mechanical signal applied

Theory of Operation

Principles of Synchro Action: The synchro consists of a rotor and a stator, each of which carries one or more windings to which electrical voltages may be applied or from which electrical signals may be obtained. If an electrical signal (voltage) is applied to one of these windings, turning of the rotor will change the geometric relationship of this energized winding with respect to the others. Because alternating current has been used for the input signal there will be induced voltages in the nonenergized windings which will vary in some manner with rotor position. These induced voltages constitute an output electrical signal which is a combination of the input electrical signal and a mechanical signal, i.e., the rotor angular displacement. The meaning of this output depends upon the design of the particular unit.

Conversely, if electrical signals are applied to both the rotor and the stator windings, the resultant currents flowing will produce a mechanical torque on the rotor. By this means, two electrical signals are transformed into a mechanical one.

The first conversion to be considered will be that of angular position to electrical voltage. In its most elementary form this action is shown in *Fig.* 3. A magnetic field is set up by pole pieces *A* and *B* and is constant in direction but alternating in time because it is produced by an alternating current flowing in the primary coil *P*. Coil S (shown in cross-section) in this magnetic field may be rotated about an axis through *O*. Because the flux through coil S depends upon θ, the angular displacement of the plane of S from some reference direction, a voltmeter connected across the two open ends of the coil will change its reading with θ. This variation of the voltage is shown in *Fig.* 4. It will be observed that considerable ambiguity would arise if this voltage were to be used as a position signal. This problem, however, is easily eliminated by use of three coils, each similar to *S*, with planes spaced at intervals of 120 degrees around the rotor axis. The unit thus described may be represented schematically as in *Fig.* 5.

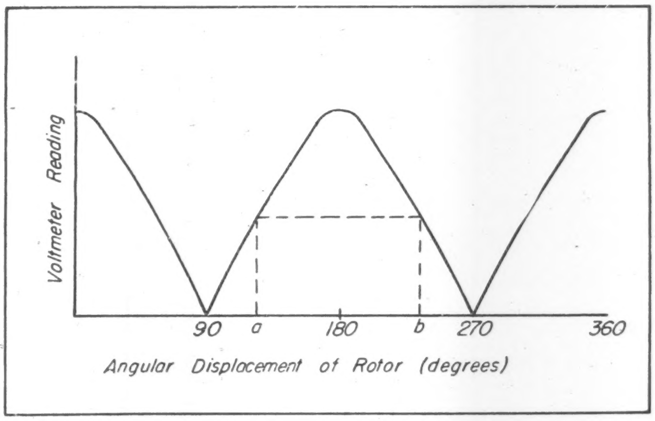
Although the magnitude of the three voltages is the same for angular displacements of 180 degrees, the electrical time phases of the voltages are not. Each time one goes through zero, its particular time phase changes by 180 electrical degrees, which is equivalent to multiplying the voltage by minus one. Consequently, the device will give a unique set of voltages for each angular position of the synchro motor. It is important to note that if the rotor is stationary or moving at a slow speed relative to the frequency of the applied ac voltage, the three voltages do not constitute a set of three-phase voltages in the ordinary sense. They are all in time phase, or 180 degrees out of phase with themselves and also with respect to the input voltage.

It is usually more convenient because of mechanical considerations to reverse the role of the rotor and stator as shown in the schematic, *Fig.* 3, so that the three coils are on the stator and the primary winding is on the rotor. This convention will be followed hereafter in this article, but involves no change in the electrical principles of the situation.

If a set of three coils in a synchro of the type just described is energized by a set of three voltages corresponding to a position signal, current will flow in the windings and an alternating magnetic field will be set up in each coil. The direction of the magnetic field will be parallel to the coil axes (perpendicular to the coil plane). Inasmuch as the voltages are in electrical time phase—or 180 degrees out of phase—these three fields will combine to produce one field, pulsating in time but fixed in direction as shown in *Fig.* 6. The reason the resultant is fixed in direction is that the three magnetic fields are changing magnitude at proportional rates.

Where the electrical signal applied to produce these magnetic fields is generated by the unit shown in *Fig.* 5, this resultant magnetic field has two important properties:

1. Amplitude is independent of the angular position of the rotor which generated the electrical signal
2. Resultant magnetic field and primary magnetic field of the generating unit have identical directions when referred to corresponding points on the two units.



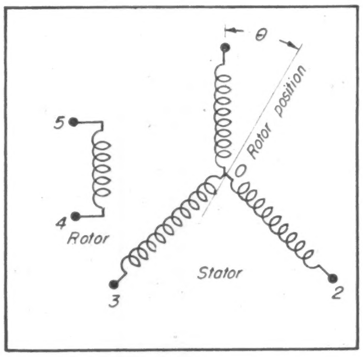


Fig. 4—Above—Relationship of angle of rotor position (input signal) to voltage output of the transmitter

Fig. 5 — Left — Schematic electrical circuit of the synchro. Rotor is excited by single-phase voltage, output is three wire

Consequently in the circuit shown in *Fig.* 7, rotation (by turning its rotor) of the primary magnetic field of unit *A* will cause the resultant magnetic field in unit *B* to rotate with it in exact angular synchronism. An unrestrained magnet placed in this magnetic field would then line up with the *resultant* magnetic field.

Basic Types and Circuits: With an understanding of the principles underlying synchro action it is now possible to analyze some of the basic types of synchros and the circuits in which they are used.

Transmitter-repeater: In connection with *Fig.* 7 it was indicated that a magnet placed in the field of unit *B* will reproduce the rotor direction of unit *A*. This is an important property of synchros and thus remote indication of angular position is possible, the three wires joining the secondaries being the only intermediate connections necessary. Magnet used in the repeating unit *B* is energized by the same source of voltage as is the primary of unit *A* in order to preserve electrical time phase relations. This is indicated in the circuit diagram and when used in this way, unit *A* is called the transmitter, unit *B* the repeater.

Voltage Relationship

Operation of the circuit has already been explained in terms of magnet fields. There is, however, another way of viewing the action which gives a little more insight into the behavior of the circuit. Each one of these units if looked at by itself is a generator of an electrical signal. This signal corresponds to the angular position of the rotor. By proper adjustment of turns ratios between the primaries and secondaries of the two units, the electrical signals corresponding to identical angular positions of the two units can be made the same. Consequently, when the two rotors are in synchronism (identical angular positions), the two sets of voltages will just balance out. For example, the voltage from 0 to 1 in the transmitter will be opposed by an equal voltage from 0′ to 1′ in the repeater. The same condition of balance will prevail in the other three legs so that no current flows anywhere in the secondary circuit. If the rotor of the transmitter (or repeater) is turned from the synchronous position the voltage balance will be destroyed and secondary currents will flow. These currents will react with the primary magnetic field of the repeater to produce a torque on its rotor, the direction of this torque being such as to return the units to synchronism. If this latter rotor is free to turn, synchronism will be re-established. It is of interest to note that a similar torque is applied to the rotor of the transmitter as long as asynchronism exists.

If the rotor of the transmitter is clamped at some position, a measurement may be made of the torque required to turn the rotor of the repeater as a function of its angular displacement from the synchronous or base position. The curve of *Fig.* 8 results. Slope of this curve at zero angular displacement is of considerable importance in judging the performance of the system and is usually measured in ounce-inches per degree. Using this quantity it is possible to compute the angular error resulting from any loading of the repeater rotor. For small angles less than about 30 degrees, the formula $E = L/T$ may be used, where L = torque load on repeater shaft in ounce-inches, T = torque gradient in ounce-inches per degree, and E = angular displacement of the system from synchronism in degrees. The value of T varies from 0.02-ounce-inches per degree for small units, to as high as 4 ounce-inches per degree for large ones.

Transmitter-differential-transmitter: The differential is a unit similar to the transmitter but having two, 3-coil windings, one on the stator as has the transmitter and the other on the rotor. *Fig.* 9 is an example of a circuit in which this unit is used.

This type circuit may be used to add and subtract angular positions. Each of the transmitters generates a magnetic field in the differential, the differential stator windings setting up the magnetic field for transmitter *A* and the differential rotor windings performing the same function for transmitter *B*. The direction of each of these fields is identical with that of the generating transmitter rotor if measurements are made from analogous points on the windings. If it is desired to make the differential add instead of subtract it is necessary merely to interchange leads 2 and 3 on either transmitter *B* or on the differential winding to which it is connected. This has the effect of reversing the direction of rotation of the magnetic field generated by transmitter *B*.

Transmitter-transformer: This third circuit to be considered has become in many ways the most important because of its inherent advantages in the control of electrical servomechanisms. Furthermore, its overall accuracy is higher than any of the systems thus far described.

A schematic diagram of a transformer is exactly the same as for a transmitter or repeater. However, the single-coil winding on the rotor is not connected to a source of power but is used as a search coil. If a magnetic field is set up in the transformer by connecting its stator windings to a transmitter the direction of this field may be found, since the voltage induced in the search coil by the magnetic field depends upon their relative angular positions. In particular, when the magnetic field lies in the plane of the search coil this induced voltage is zero. The reading of an ac voltmeter connected across the search-coil terminals is shown in *Fig.* 10 as a function of the angular departure of the system from the synchronous position, this latter being defined as the position of zero voltage.

While two positions of synchronism are apparent in *Fig.* 10, one at 0 degrees and the other at 180 degrees, it is possible to distinguish between them by making use of the electrical time-phase change of 180 degrees in the output voltage occurring at these points. Between zero-voltage points the time phase does not change. If turning clockwise through one of these nulls, the time phase changes by 180 degrees, then turning clockwise through the other will change the time phase by minus 180.

The amplitude of the output voltage of a transformer plotted as a function of its angular displacement from synchronism very closely approximates a sine curve although *Fig.* 10 shows the entire function as being positive. This is because a voltmeter is not sensitive to electrical time phase but only to the absolute value of the voltage.

Field of Application: The principal application of synchros may be broken down into three main categories: Remote indication, remote control and automatic computation. Each of these will be discussed in turn.

Remote indication: Synchros were first used in the solution of the problem of remote indication and until fairly recently this was by far their principal employment. The transmitter-repeater system is of course admirably suited for this purpose. In selecting the particular types of these units for any particular application, the choice is based almost entirely upon the accuracy required.

A major source of error in transmitter-repeater systems is bearing and brush friction, the effect being to create a dead-space, or angle of poor response, about the synchronous position. The width of this dead-space is inversely proportional to the torque gradient of the system and hence may be reduced by increasing this quantity. *Fig.* 11 shows the torque gradient for systems having transmitters and repeaters of equal weight plotted as a function of the weight of either unit. The values used

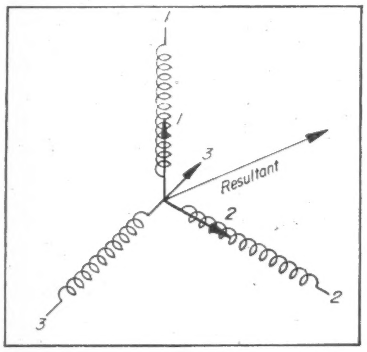


Fig. 6 — Magnetic fields produced by each of the windings combine to give the vector resultant

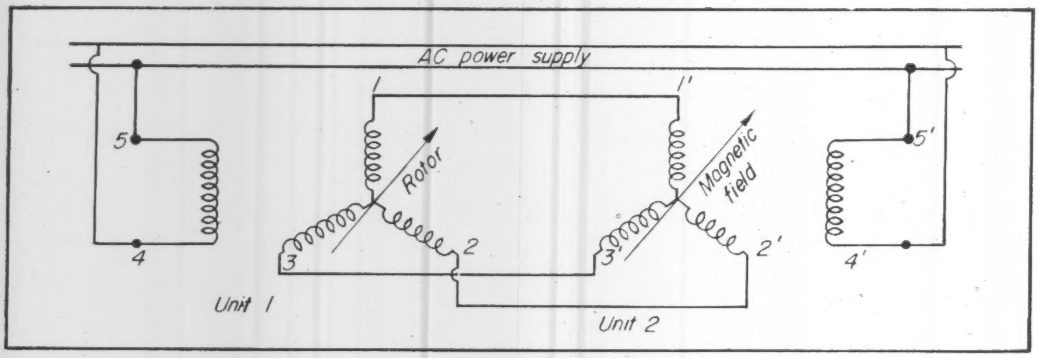


Fig. 7—Electrical diagram of a transmitter-repeater circuit. Repeater has same magnetic field as transmitter, and therefore rotor assumes an identical position

to establish this curve are based on representative Army and Navy instrument synchros with temperature rises of between 40 C and 50 C. When plotted on log-log paper, the points fall approximately on a straight line so that the equation, $T = 0.041W^{1.6}$ ounce-inches per degree where W is in pounds, is satisfactory for estimates.

The overall frictional torque acting on the rotor of a repeater or differential repeater is an elusive quantity to specify because it depends upon a great many variables which cannot be controlled. It is thus usual to require that the maximum value of this frictional torque shall not exceed some nominal value when the unit is new, and a value of 0.25-ounce-inches has been fairly generally chosen for this purpose. An estimate of the overall frictional dead space may be made on the basis of the torque vs weight data discussed above. For values of frictional torque of 0.25 and 0.10-ounce-inches, the estimated dead space is plotted in *Fig.* 11 as a function of the weight of the unit.

To determine the overall error of a transmitter-repeater circuit it is necessary to add the frictional and the electrical errors. This latter error is failure of the magnetic field of the repeater to follow exactly the transmitter rotor and is usually caused by eccentricities in the units themselves. With precise manufacturing this error may be made as small as desired but it becomes very difficult to reduce its amplitude below 0.2-degree. In some less-precise units it may run as high as 1.0 degree.

When extreme accuracy of transmission is required, recourse can be had to multispeed systems. The data are then carried by two or more transmitter-repeater systems, one transmitting "coarse" information and the others "fine". In the case of a two-speed system, the fine transmitter is so geared to the coarse that the former makes a large number of revolutions while the latter makes but one. If n is the gear ratio, then an n-fold decrease in the error is possible. By using further channels the error may be made correspondingly smaller, subject of course, to the accuracy of the gearing itself.

In multichannel systems, and sometimes in single-channel ones, it is important to avoid driving the synchros at excessive speeds unless adequate precautions have been taken in design of the slip-rings, brushes and bearings. Regardless of the speed, however, transmitter-repeater systems will always synchronize as under static conditions.

It is not advisable, in general, to use the repeater to drive loads other than light dials or pointers because of the resulting error. Even if the error can be tolerated due regard must be made to the increased temperature rise caused by the secondary currents which increase rapidly with asynchronism.

In case remote indication of either sums or differences of positions is required, the differential systems outlined previously are quite suitable. Differential repeaters have lower torque gradients than do conventional repeaters of the same weight so that allowance for the increased friction error is necessary. For units of the same weight and temperature rise, the torque gradient for a differential repeater is from 1/2 to 2/3 that of the repeater.

Remote control: The field of application of synchros to a remote control problem is so great that only a cursory examination will be made here. Either of the two differential systems previously discussed is useful because in either case connections may be made to give the difference between the positions of the two input shafts. If a hydraulic servo is used, this difference in position can displace a control valve in the direction necessary to restore synchronism. Another kind of followup system utilizes the differential shaft to make and break electrical contacts thereby turning an electric motor on and off.

When electrical servos are to be used, however, by far the most convenient system is the transmitter-transformer. Its output is a signal whose amplitude is proportional to the sine of the angular error, and since it is an alternating voltage the signal is easily amplified to power levels high enough to operate motors. A two-phase motor may be operated directly by the amplified signal, the change in phase of 180 degrees when going through the null point

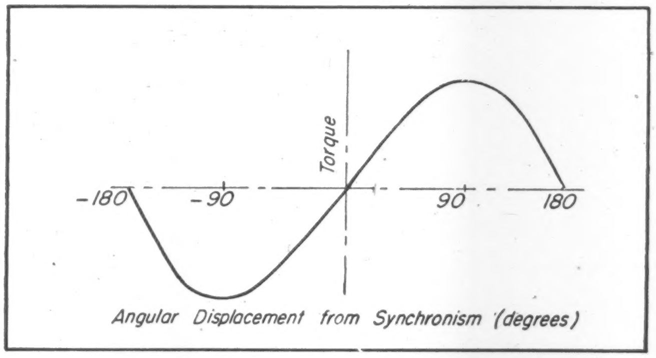
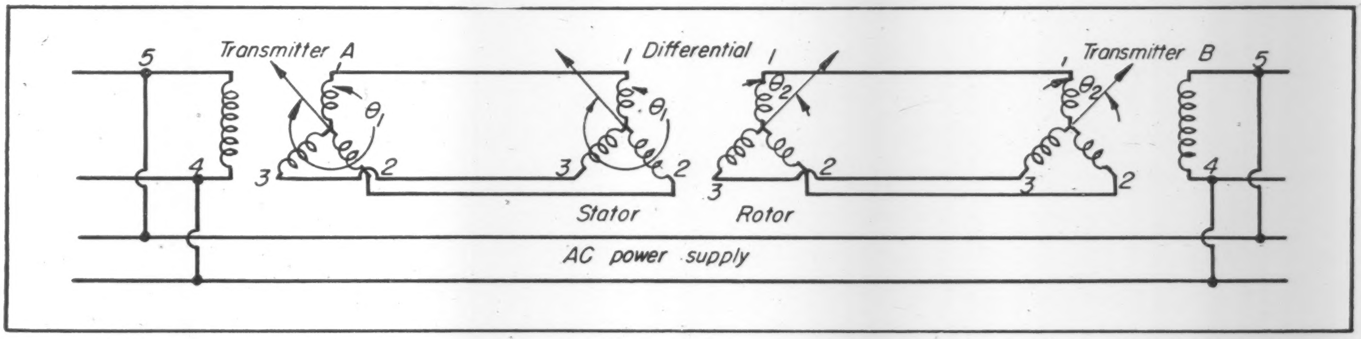


Fig. 8—Above—Relationship of output torque to displacement from synchronous position. Slope of curve where passing through zero is measure of accuracy of the unit

Fig. 9—Below—Electrical diagram of a transmitter-differential-transmitter circuit. Differential measures either the sum or the difference of signals sent from transmitters



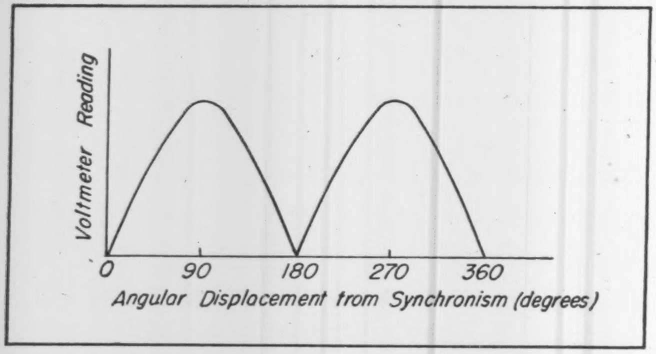


Fig. 10—Relationship of angle of synchro-transformer magnetic system with output voltage of the system

being sufficient to reverse its direction properly. When dc servo motors are used, the transformer signal is first amplified and then detected in such a way that a positive voltage is obtained on one side of the null point and a negative on the other. While the amplifiers for dc motors are usually more complicated, it is easier to provide the necessary stability controls than for ac motors.

It is sometimes necessary to have greater accuracy than is inherent in a transmitter-transformer circuit and here multispeed systems of the type described previously are used. The circuit is arranged so that the fine transformer has control for small errors, the coarse taking over for large ones. The use of an odd gear ratio, say 33 to 1, between the fine and the coarse channels eliminates the dead-space error at 180 degrees which occurs when an even gear ratio is used. If an odd gear ratio is not convenient it is necessary to include elements in the circuit to avoid this difficulty. A great many ingenious methods are available for this purpose because both the Army and Navy used even gear ratios in most of their multispeed systems.

It will be found that the null point of a transmitter-transformer system shifts from the true synchronous position as the angular velocity of the system is increased. This is because of voltage generated by the rotation. For speeds which are low, compared to the synchronous speed, 3600 rpm for a 60-cycle system, the resulting error is not serious. If high speeds are contemplated, it is advisable to use higher frequency excitation for the units. High-frequency systems have higher response characteristics and their associated amplifiers can be made with lighter components. It is interesting to note that 60-cycle units have performed satisfactorily at 80-kilocycle excitation.

The other source of error in transmitter-transformer systems is an electrical one, similar in cause and properties to the one previously described in connection with the transmitter-repeater. By properly matching pairs of units, however, this error can be made quite small compared to that existing in systems paired at random. Some companies supply units matched this way having overall errors as small as 0.05-degree while for unmatched pairs the electrical error sometimes is as high as 0.2 to 0.4-degree.

Precise measurements will indicate that even at the synchronous position a residual voltage exists. Although the voltage corresponding to the excitation frequency will be zero at this point, a number of higher harmonics produced by nonlinearity in magnetization properties remain. If this residual voltage is too large, errors analagous to the fractional dead-space become evident. Consequently the maximum permissible value of this minimum voltage is frequently specified when units are being purchased.

Automatic computation: The use of transmitters, differentials and repeaters for purposes of addition and subtraction is obvious enough to require no further discussion. The possibility of more complicated operation is offered by the transformer since its output voltage is proportional to the sine of the angle between the effective plane of its rotor coil and the direction of the signal imposed by its transmitter. A variation of the transformer uses a second coil, similar to the first but at an effective angle of 90 degrees with respect to the original one. This device, called a component resolver, generates functions which are proportional to the amplitude of the imposed field multiplied by a sine and cosine respectively. By appropriate gearing, functions of multiple angles may also be obtained thereby providing the means for setting up quite complicated trigonometric equations.

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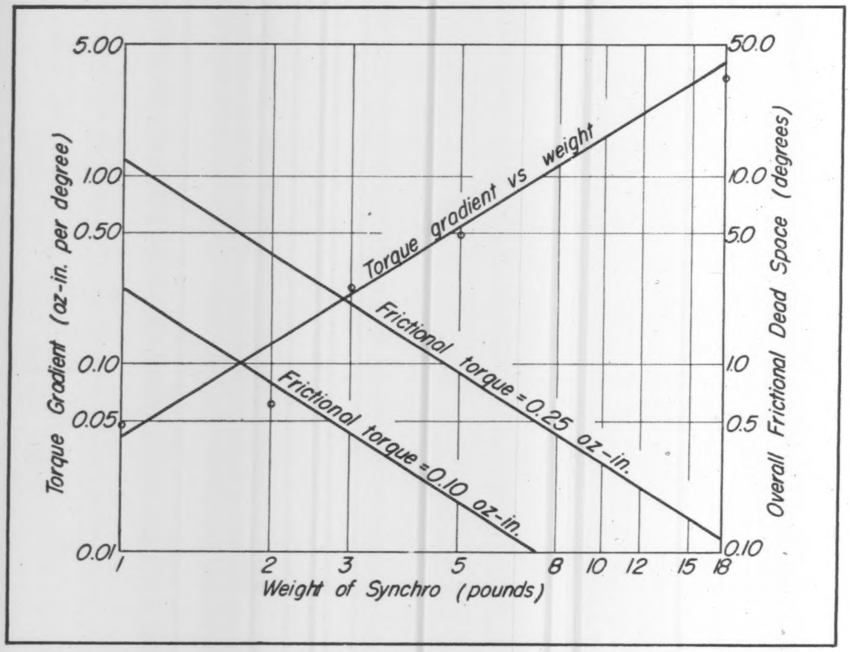
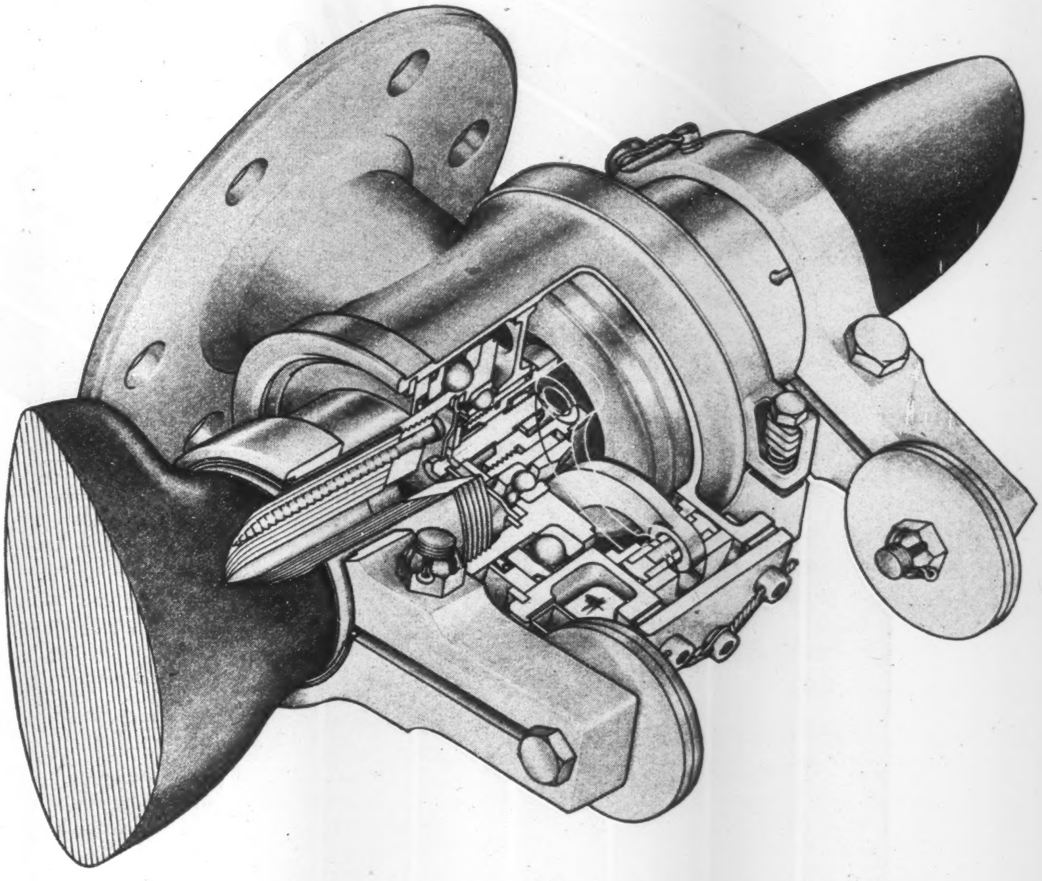


Fig. 11—Torque gradient and frictional torque plotted against synchro weight. Curves are approximately straight-line as plotted on log-log paper



Self-Adjusting Propeller

. . . employs natural forces to effect pitch changes

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DEVELOPMENT of a variable-pitch propeller in which the blade pitch change takes place automatically, without any manipulation of controls by the pilot, was prompted by the need for light-plane performance advantages similar to those which for years were available only to large military and transport aircraft. It is obvious that all the features of propeller pitch control, now a necessary part of the highly developed large plane, could not be reduced in size for use on a small plane because such a propeller would probably increase the cost of the personal plane beyond a reasonable market price. However, by starting from a different principle, it was possible to develop a propeller, the Aeromatic, which is simple in construction and requires a minimum of maintenance, yet can substantially improve plane performance.

PRINCIPLES OF OPERATION: The Aeromatic propeller utilizes the natural forces acting on the blade and on a counterweight to accomplish automatically the desired change in pitch for varying conditions of flight, without control by the pilot. The automatic operation represents a continuous state of balance between the pitch-changing tendencies of (a) aerodynamic force components of thrust and torque acting on the blade, (b) centrifugal force acting on the blade, and (c) counterweight force, to maintain a virtually constant engine speed at a fixed throttle setting and altitude, the pitch changes being stepless.

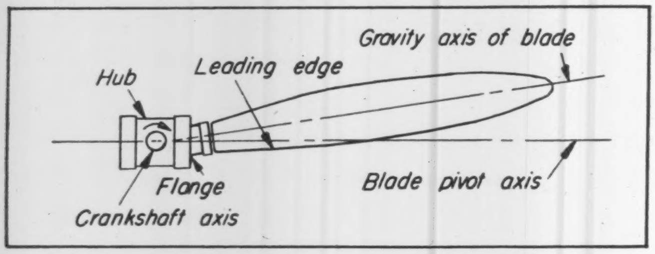


Fig. 1—Rear view of hub and blade, showing blade lag angle. When gravity axis lies in plane of rotation the lag angle is equal to the construction angle

To obtain this automatic action the principal mechanical parts—hub, blade and blade flange—are so constructed and assembled that the operating forces change their relative positions. For that reason the blade is attached to the flange at an angle called the construction angle, ϕ, which is the true angle between the gravity axis of the blade and the blade pivot axis, *Fig.* 1. The blade flange can oscillate around an axis which coincides with the centerline of the hub barrel in which it is mounted. Therefore, the gravity axis of the blade will be inclined to the pivoting axis of the flange so that the blade axis will swing along a conical arc, forward or rearward of the plane of hub rotation, *Fig.* 2. When the blade axis falls within the plane of rotation, the blade pitch angle will diminish when the blade axis swings forward of the plane of rotation, and will increase when the blade axis swings to the rear of the plane of rotation, *Fig.* 2. Furthermore, the threaded hole into which the blade fits is so inclined to the pivoting axis of the flange that the gravity axis of the blade lags in respect to the propeller rotation, *Fig.* 1. The range of angular movement of the flanges and blades is limited by adjustable stop screws, *Fig.* 3.

Modification of the blade mass is accomplished by the addition of a counterweight arm to the blade shank, the effect of which can be varied by mounting it at the desired angular position relative to the blade airfoil; magnitude of the effect may be varied further by changing the weight fastened to the end of the counterweight arm, *Figs.* 2 and 3.

FIXING THE OPERATING VARIABLES: The desired blade pitch regulation curve is established by calculating the variables which influence the operation. Numerical values of the construction angle, blade phase angle, and blade mass are determined from analysis of the forces acting on the blade, which are considered to be in equilibrium for at least two conditions, static takeoff and level flight.

Preliminary calculations for a certain installation indicate, for instance, that the useful values of the blade phase angle, γ, should fall within the range of 16 to 24 degrees and that the range of the construction angle, ϕ, would fall between 2 and 10 degrees. The counterweight magnitude, Wr^2, is then computed for several different values of γ and ϕ within this range.

Relations between the blade shank bending moment and the construction angle for various values of blade phase angle are then calculated for the two limiting flight conditions. From analysis of the range of values, a suitable construction angle is selected and incorporated in the detail design of the blade flange. This angle should result in values for the blade shank bending moment which are below the maximum allowable.

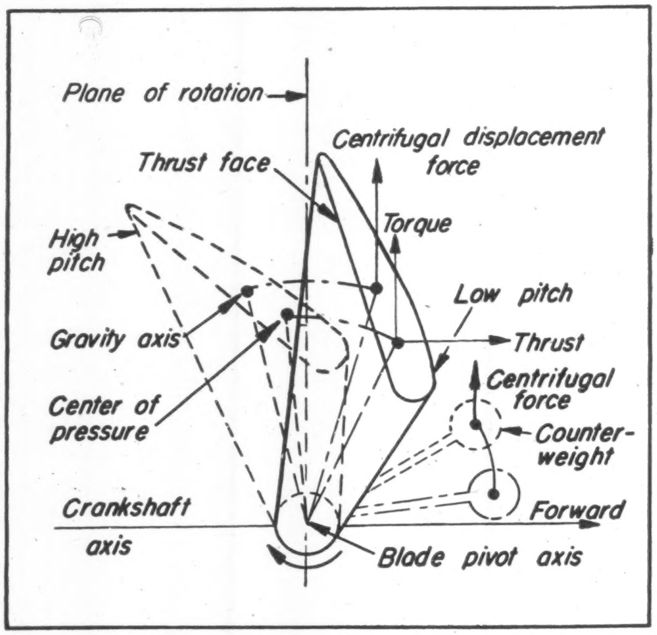


Fig. 2—Tip view of blade through center of pressure, showing high and low-pitch positions

A composite graph is shown in *Fig.* 4 comprising, first, the relation of counterweight magnitude with respect to construction angle and phase angle and, second, the relation of the allowable blade shank bending moments with respect to construction angle and blade phase angle. The curves of constant shank bending moment define a useful field of values of γ and ϕ, within which bending moments do not exceed, for this case, 12,500 pound-inches. The corresponding counterweight magnitude, Wr^2, may be read for any such pair.

PROPELLER SETTING: Determined by means of the foregoing calculations, the following data are used in specifying the settings during assembly of the propeller for a specific application:

1. Construction angle—built into the flange

2. Blade phase angle—which determines the angular setting of the blade in relation to the blade flange
3. Angular setting of the counterweight arm and the amount of weight on the end of the arm
4. Setting of low-pitch and high-pitch blade angle stops —limiting the range of blade change.

The various parts of the propeller are assembled to these data. Settings are later checked or slightly modified during the flight tests of the original installation. Thereafter, all propellers for this type of plane and engine combination are assembled identically.

Design: Two different designs of light-plane engines call for corresponding propeller designs. The first design is similar to those used on large aviation engines on which the crankshaft extension carries the propeller, *Fig.* 3. The second design accommodates engines provided with a crankshaft flange, to which the propeller can be fastened and which is widely used on engines from 65 to 150 horsepower. This type is shown in the illustration at the beginning of the article.

Typical of the first design is the installation shown in *Fig.* 3. The propeller hub is fabricated from steel tubing, bored out to fit a crosstube which is welded to it to form a single unit, *Fig.* 5. Hub material is chrome-molybdenum steel of around 0.30 per cent carbon content. The piece is heat treated to give 135,000 psi tensile strength, actual maximum working stress being 35,000 psi. The hub barrel is machined to receive the two blade flanges, which are supported on ball bearings and which are designed to hold the blade at a fixed angle to the blade pivot axis about which the blade turns to change its pitch.

With the blade free to pivot, the thrust force acting on the center of pressure of the blade tends to turn the blade forward, *Fig.* 2. The thrust, being maximum at take-off condition, decreases the pitch and puts the blade into extreme low-pitch position, corresponding to low gear in an automobile transmission.

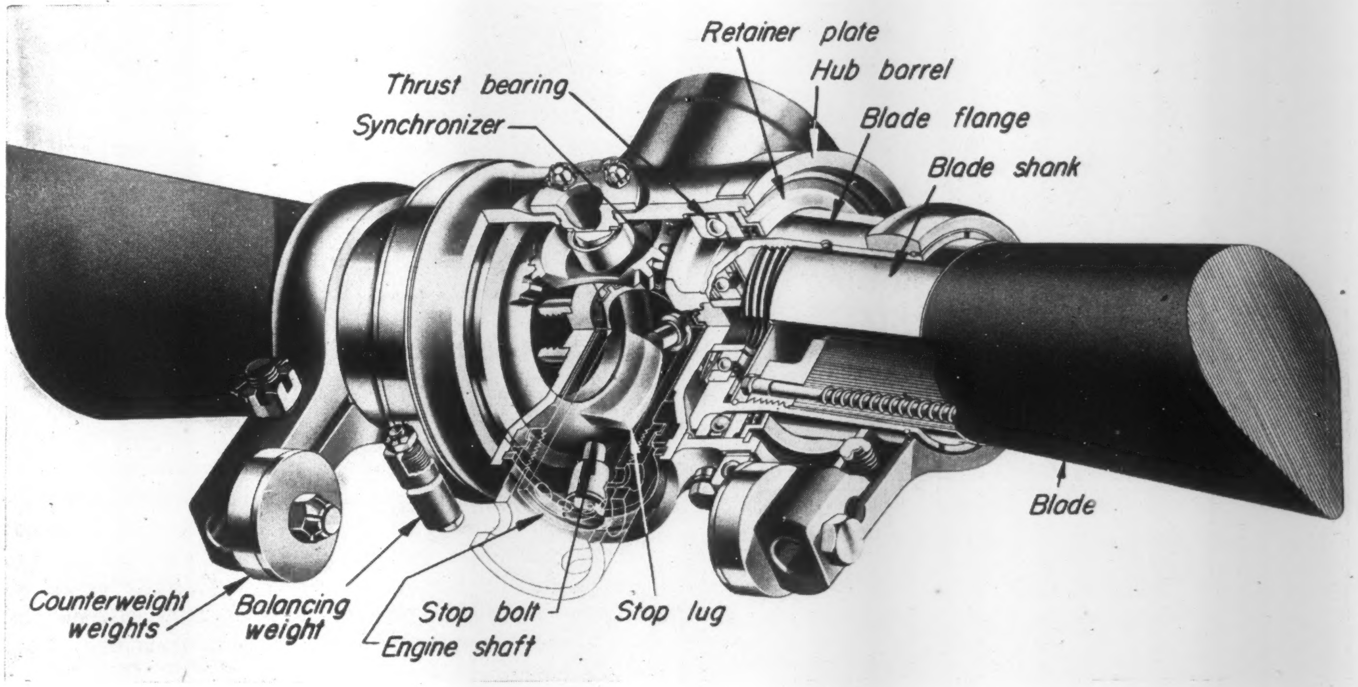
The flanges are screwed into the blade shanks and carry ball bearings which are held in place by retainer plates and snap rings. Flanges and retainer plates, likewise, are chrome-molybdenum steel. The oscillating movements of the two flanges are synchronized by a set of bevel gears which are an integral part of the flanges and which are kept in proper phase by means of a bronze idler gear mounted on a stub shaft on the side of the hub barrel. Range of the oscillating movement is fixed by four stop screws, located on the side of the hub barrel, which are adjusted to give the required high-pitch and low-pitch positions of the propeller blades.

Counterweight Arms Serve as Clamps

Counterweight arms and weights are oriented and set in front of the plane of propeller rotation at a fixed angle with respect to the blade. The arms also function as a clamping device to hold the blades in the flanges, the whole unit of blade, flange and counterweight arms acting as one integral mass. Net centrifugal force of this mass tends to increase the blade pitch, *Fig.* 2.

Propeller Blades: The blades are manufactured from 1/16-inch laminated veneers and formed into blocks under heat and pressure, using phenolic resin as the binder. The blade blocks are first sawed out to approximate contour, then the ends are turned and the steel ferrule pressed on these shanks. Referring to *Fig.* 3, the wood portion of the blade is fastened to the threaded ferrule by a large number of wood screws of various length to distribute the ends of the screws over different cross-sectional planes and thereby diminish localized stresses. Each of the screws has a load capacity of 5000 pounds against the centrifugal force trying to pull the wood out of the ferrule. The blade blocks are profiled on the carv-

Fig. 3—Sectional view of Aeromatic propeller for applications of 150 to 300 hp, using a No. 20 splined shaft



ing machine, and the finished carved blade is covered with a plastic sheet which protects the blades against moisture absorption and abrasion.

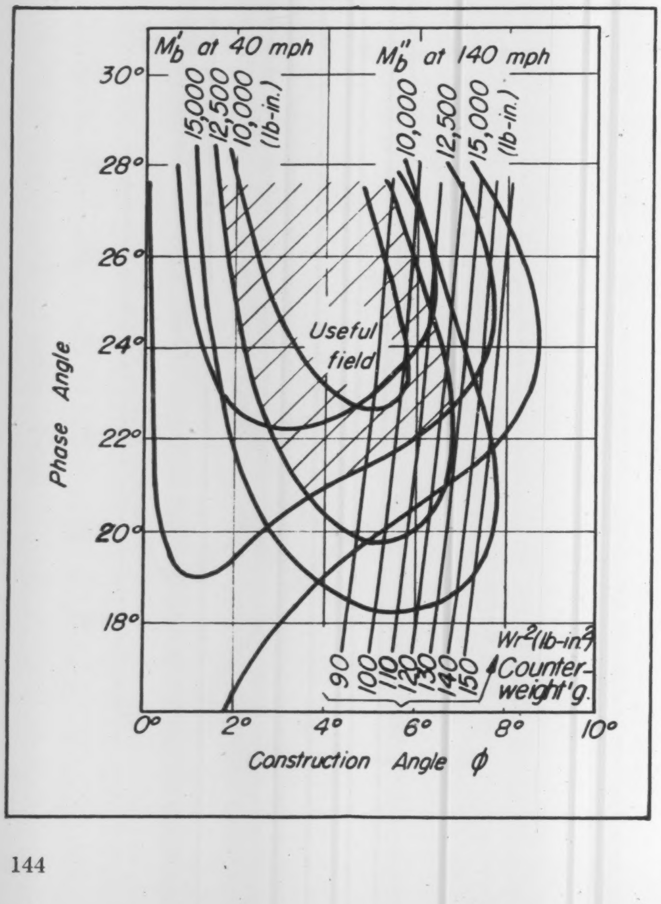
As previously noted, the design of propeller hub suitable for flange-type engines is shown in the head illustration. The main difference is the construction of the synchronizing mechanism and the elimination of the center crosstube, allowing considerable shortening of the hub barrel and corresponding weight saving. The synchronizer consists in this design of two connecting rods, one hinged to each flange and mounted to a crosshead which is guided within a cylinder, thereby assuring synchronized oscillating movement of the flanges and blades.

DETAIL DESIGN: The two designs illustrated show the following additional detailed features:

Thrust Bearing: These carry the centrifugal load of the blades. Curvatures of the ball races and the ball retainers are designed to give low friction so that the oscillating movement of the blades is free from drag and hunting. Instead of using solid ball retainers for the thrust bearing, the balls are held in a wire cage which permits spacing them sufficiently close to let the path of one ball overlap the path of the next one. Such construction results in larger load capacity of the bearings and improves the surface of the ball races. This is of importance when considering the oscillating movement of these bearings compared with the usual rotating installation of antifriction bearings.

Preloading: The flange and thrust bearing assembly is preloaded by a screw type of sleeve located in the center of the hub, which allows the flange assembly to be pressed outward against the large snap ring. To reduce friction this preload pressure is transmitted from the center portion of the hub by means of a radial thrust bearing pivoted around the preload device. A serrated plug locks this assembly.

Fig. 4—Relation between counterweight magnitude, construction angle, and phase angle for a particular design



Balancing: Balancing bands installed on the end of the hub barrels are provided with hollow sockets. These are loaded with lead disks until horizontal balance of the assembly is obtained. Then the propeller is turned 90 degrees on the balancing stand, and the bands are shifted around the hub barrels until vertical balance is obtained.

Mass Production: Design of this propeller lends itself readily to mass production, inasmuch as detail parts for one particular model can be assembled to fit the various installations on all plane and engine combinations covered by the particular model.

Lubrication: As mentioned, the friction between moving parts must be held to a minimum, requiring a lubricant which remains in a fluid state even at very low temperatures. This feature requires that packings around the blade shank be sufficiently tight to prevent the lubricant from being thrown out when the propeller is whirling between 2000 and 3000 revolutions per minute. On the other hand, these packings must be so free fitting that they will not cause drag on the free-swiveling propeller blades. These two conflicting requirements are satisfactorily solved in the design of the packing which fits against the blade flange. With this type of packing, it was possible to hold lubricant of a viscosity equal to SAE-10 engine oil without leakage at all engine speeds.

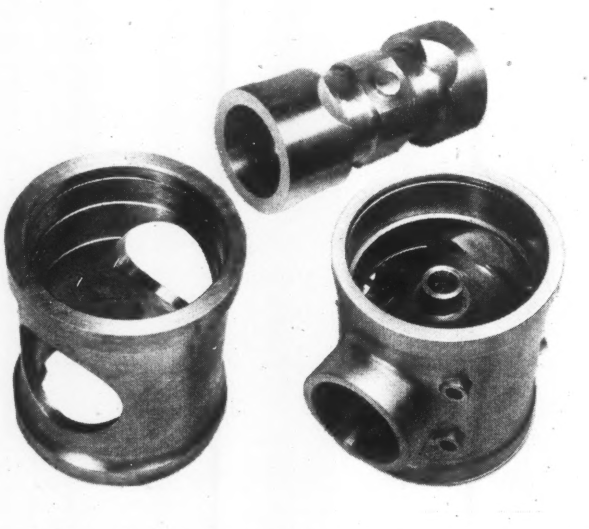
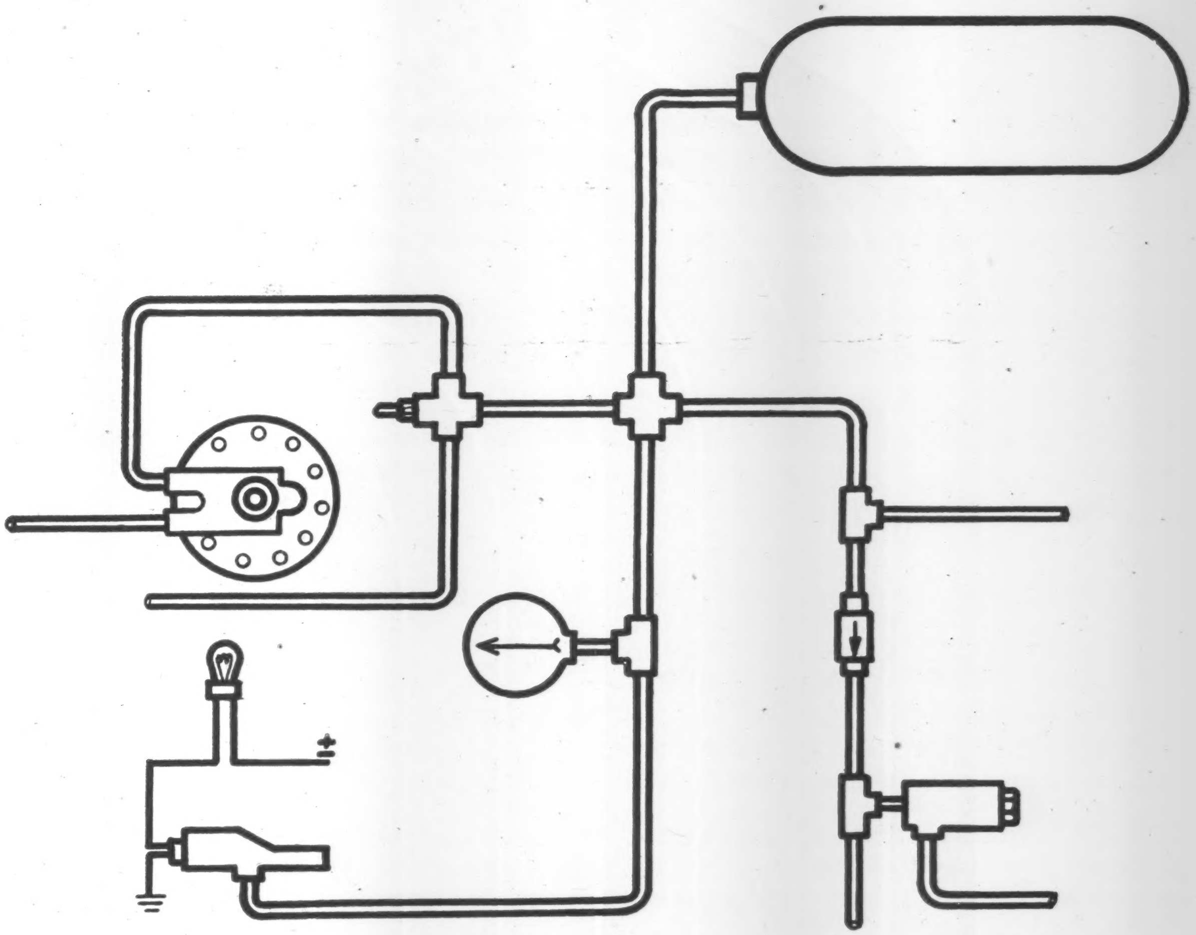


Fig. 5—Hub shell and crosstube before welding, and the completed hub after welding and finish machining

All outside steel parts are protected by cadmium plating and the inside of the hub is filled with lubricant which contains a rust-inhibitor substance. Service operation for the Aeromatic propeller consists of periodical inspection of the oil level in the hub. Otherwise the few moving parts require inspection only at a major overhaul of the engine.



Applying Hydraulic Accumulators

By Edward M. Greer

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Part I–Accumulator Characteristics

DUE to its virtual incompressibility, fluid cannot be stored dynamically in an ordinary vessel or chamber. In other words, if a chamber is totally filled with a fluid under any pressure, say 5000 psi, the loss of as little as two per cent of the fluid would immediately drop this pressure to zero. Thus in a closed hydraulic system, rapid drop in pressure due to system leakages as well as sudden build-ups that occur naturally, give rise to shock and surge conditions that often prevent proper holding or moving of loads.

Practical dynamic fluid storage for machine hydraulic systems, however, is readily accomplished by means of a hydraulic accumulator which, happily, can also be used

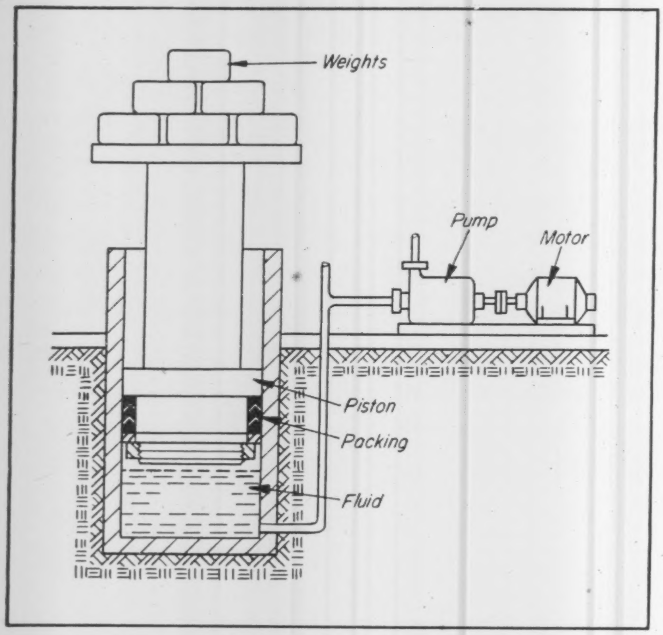


Fig. 1—Typical direct type gravity accumulator used extensively in operating large tonnage hydraulic machines

effectively as a shock eliminator and surge chamber by careful selection of size and positioning in the system. Specifically, a hydraulic accumulator is a mechanism in which the potential energy of a fluid can be stored against some dynamic force to do useful work as called upon by the hydraulic circuit in which it is used. It is analogous to the well-known storage battery in an electric circuit.

This ability to do useful work whenever the need is present is especially valuable where operation must be guaranteed regardless of pump breakdown or failure as well as in instances where pumps lack sufficient capacity to do the necessary work. Also, by storing fluid energy in a system that has only intermittent-duty service, as most systems have, much smaller pumps and motors can be used, resulting in more efficient and dependable hydraulic circuit installations.

Summarizing briefly, the application of accumulators in hydraulic systems can be made in any one of a number of ways: (1) As a leakage compensator (in closed or pressure-regulated circuits); (2) as a surge chamber or shock absorber; (3) as an emergency source of fluid power; (4) as a means for operating secondary hydraulic systems; (5) as a pressure-volume compensator (for thermal expansion, etc.); (6) as a dispenser of fluids under pressure; and (7) as an auxiliary source of energy to pumps in intermittent-duty systems. In this article, hydraulic accumulator design and proper application in these various types of circuits will be fully covered and discussed relative to assuring maximum service and efficiency.

Development of New Design Widens Possibilities

Although the use of accumulators in hydraulic systems is not new, only limited application has been made to date due to the fact that until the development of the separator type pneumatic accumulator, efficient application was extremely difficult. This new type of small, economical unit has been made available only since the end of World War II and is rapidly finding many applications in hydraulic circuits. To enable the reader to evaluate competently and completely the various accumulators, a description of all types will be given.

Gravity Type: The earliest form of accumulator, described as the "gravity type", is still used extensively in stationary industrial applications today. This unit, as shown in *Fig.* 1, usually consists of a vertical heavy-wall steel cylinder into the smoothly ground bore of which is fitted a piston containing suitable packings. On top of

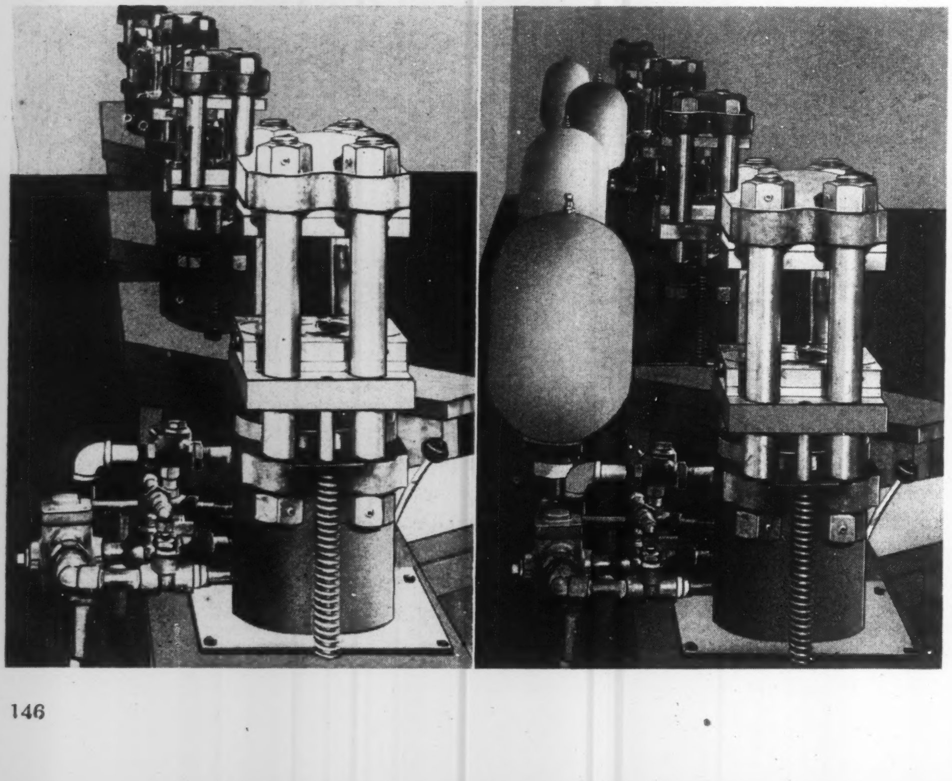


Fig. 2—Line of presses serviced by a gravity accumulator, a, extreme left, are far more vulnerable than those with individual units, b, left

the piston rod is mounted a platform on which weights are placed corresponding to the pressure desired in the cylinder. Thus, gravity is made the dynamic agency. The great advantage of this type of accumulator is that constant pressure is available throughout the full stroke of the piston. This is a characteristic not found in any other type. The greatest disadvantage is the high cost of fabrication and installation. Another disadvantage is that, due to its high cost, it is generally necessary to operate multiple services from such an accumulator, *Fig. 2a*. It can be readily seen that if the one large accumulator should fail, all the presses in the plant would be incapacitated. However, if each press is equipped with an inexpensive separator type accumulator as shown in *Fig. 2b*, a failure in one press will have no direct effect on the other presses.

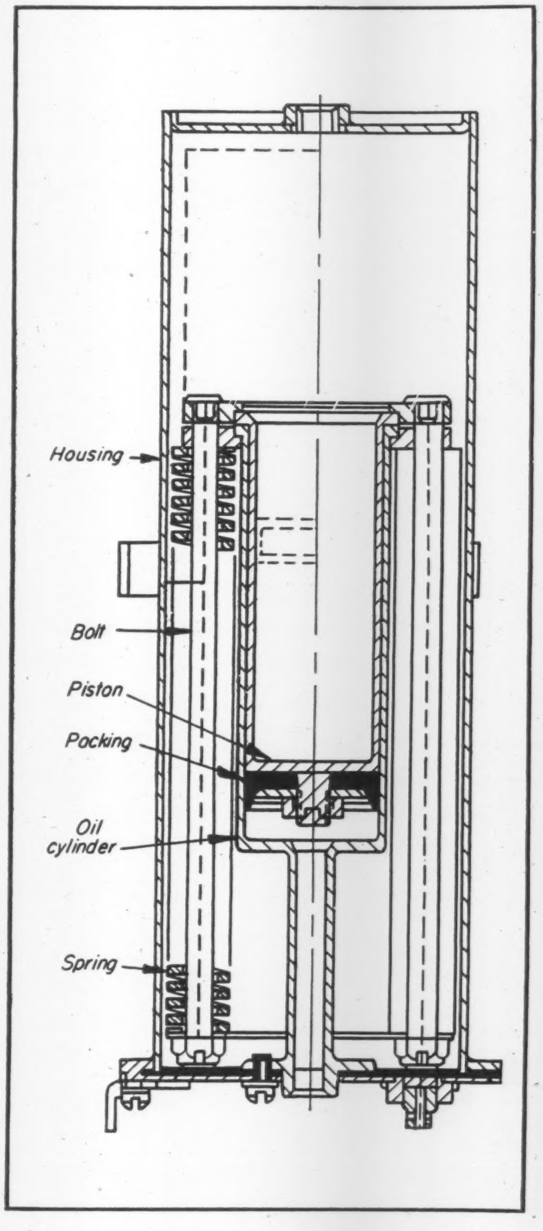
In order to obtain sufficient accumulated fluid, the industrial gravity type accumulator is generally large and cumbersome. Maintenance of such a unit is extremely expensive due to the size of the piston and rod; also, packings wear and leak and, when the hydraulic medium is water, the corrosion problem is present while salts and minerals eventually deposit on the bottom of the piston. A large failure in the line leading from the accumulator in one installation allowed the piston and weights to drop so suddenly that the impact on the bottom not only caused complete failure of the accumulator but also cracked the foundation of the building.

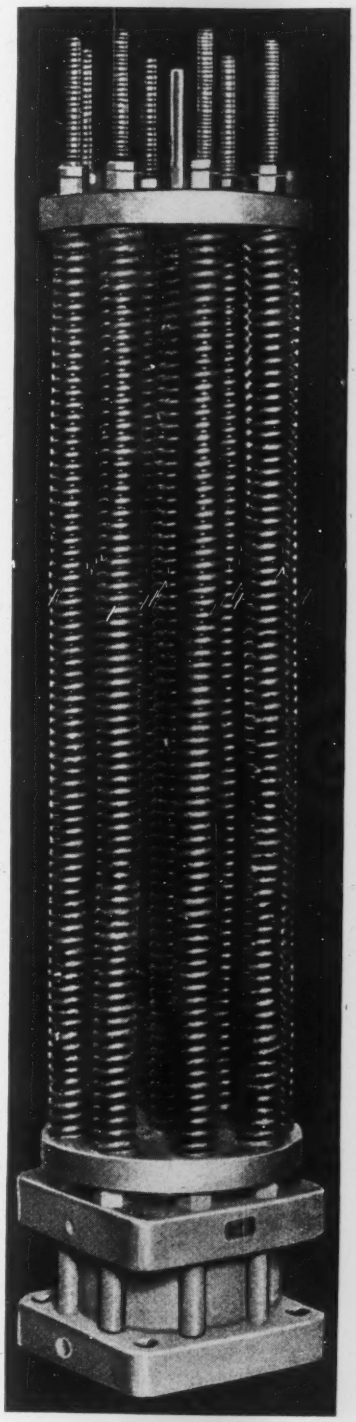
Spring Type Extremely Limited

Spring-Loaded Type: In order to compensate for system leakage and to absorb surges on mobile units such as dump trucks, snow plows, bulldozers, and marine installations, the spring-loaded accumulator was developed and is still used in limited applications. This unit, two versions of which are shown in *Fig.* 3, consists essentially of a piston with suitable packing closely fitted into a cylinder. Located about the periphery of a disk mounted on the end of the piston is a series of axially fixed rods supporting a like number of compression springs. These rods pass freely through a second disk attached to the cylinder against which one end of the springs bear, the opposite end of the rods retaining the other end with an adjustable nut. These springs are compressed, to correspond to the minimum pressure required in the circuit, by tightening the adjusting nuts. Then, as fluid is pumped into the chamber, the piston rises, further compressing the springs and loading them to correspond with the increased pressure developed. The volume of accumulated fluid at pressures corresponding to any position of the piston is dependent on the rate and loading of the springs as, in this type of accumulator, the dynamic force is the spring load.

Primary disadvantage of this type of accumulator is that only a small amount of fluid can be stored to do useful work in comparison to the size of the accumulator. As an example, a unit 9 inches in diameter and 16 inches long, weighing approximately 50 pounds, will accumulate a total of 10 cubic inches of fluid. With larger quantities of fluid, an accumulator of this type would become too

Fig. 3—Two versions of the spring-loaded accumulator, the capacity of which in any case is somewhat limited





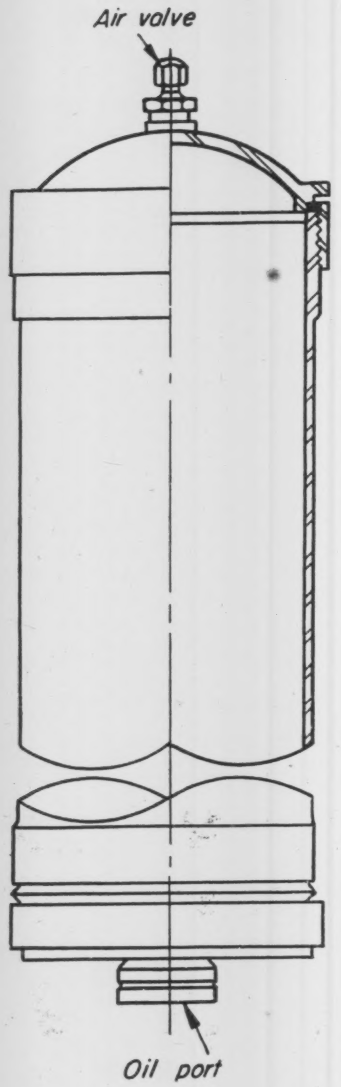

Air valve
Oil port

Fig. 4 — Left — Simplest form of hydropneumatic acumulator, lacking a separator, is restricted in use by aeration problems

cumbersome and costly. It is, therefore, used merely as a surge chamber and is rapidly becoming extinct as the pneumatic types become available.

Pneumatic Types: Pneumatic type accumulators, which are proving themselves much more practical than those described above, may be divided into two classifications: (1) Nonseparator type, and (2) separator type. The separator type has a means of sealing the gas from the fluid and is a natural outgrowth in the development of the nonseparator type.

The simplest type of hydropneumatic accumulator, as shown in *Fig.* 4, consists of a fully enclosed shell containing a fluid inlet port on the bottom and a pneumatic valve, such as that used in automotive tire tubes, on the top. To place such a nonseparator accumulator in service, a small quantity of fluid is pumped into the chamber and trapped on the bottom; then, air or nitrogen is forced through the pneumatic valve to the minimum system pressure requirements. This is known as precharge pressure. As additional fluid is pumped into the chamber, the gas is compressed further in accordance with Boyle's Law, $P_1V_1 = P_2V_2$. In this way, a large volume of fluid can be accumulated to do useful work using the compressed gas as the dynamic medium. The one great disadvantage of this type of unit is the aeration or mixture of fluid and gas. To prevent the air from being exhausted into the hydraulic system, only two-thirds of the accumulated

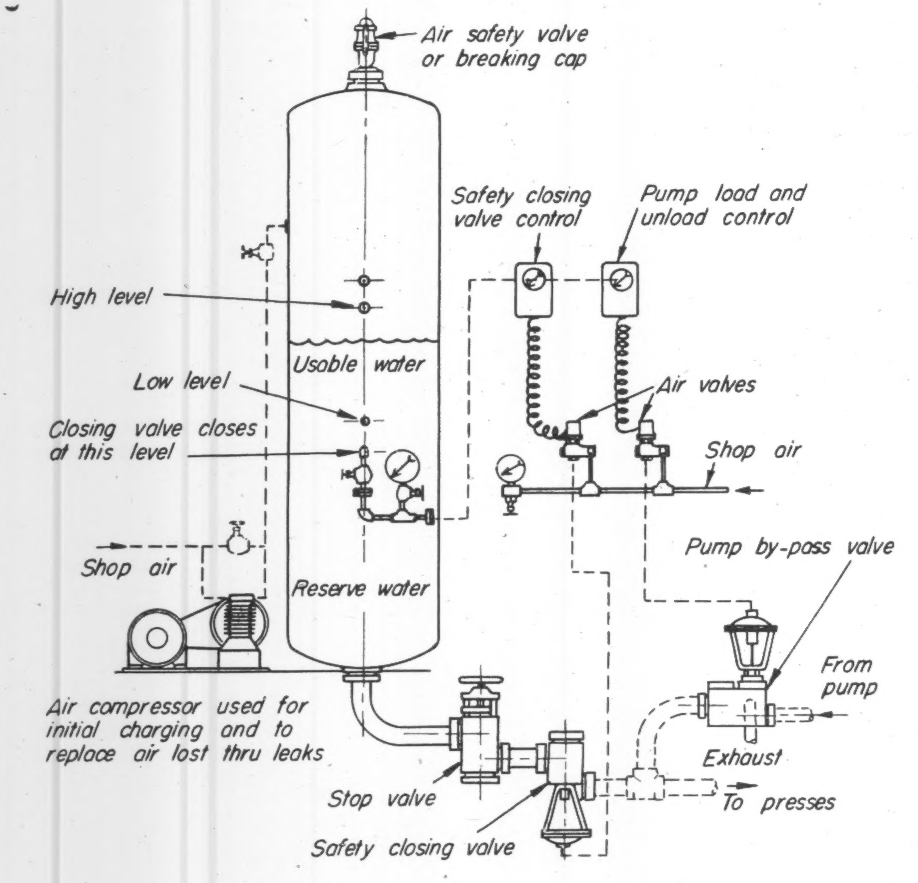

Air safety valve or breaking cap
Safety closing valve control
Pump load and unload control
High level
Usable water
Low level
Closing valve closes at this level
Air valves
Shop air
Shop air
Reserve water
Pump by-pass valve
From pump
Air compressor used for initial charging and to replace air lost thru leaks
Exhaust
Stop valve
To presses
Safety closing valve

Fig. 5 — Right — Elmes pistonless type, air-ballasted hydraulic accumulator for large-volume systems. Safety closing valve and pump bypass valve are actuated by shop air while the high-pressure compressor is used only for initial air precharging and to replace air losses

fluid volume can be used, and the unit requires careful handling. Furthermore, this type accumulator must be mounted in a vertical position and cannot be shaken for fear of aeration and thus lends itself primarily to large, permanent installations, *Fig.* 5. It can readily be seen that a separator or sealing means between the gas and fluid is desirable and imperative in installations subject to vibration or movement.

An accumulator which employs a floating piston as a separator is shown in *Fig.* 6. It consists of a cylinder whose bore is ground and honed to a fine finish and fitted with a separator piston. The packings shown in the illustration are O-rings which are suitable up to 1500 psi; above these pressures, V-ring packings are usually used and placed in such a manner as to seal the gas from the fluid. In most designs, four rings are placed with their lips facing the fluid chamber and six packings with their lips facing the gas chamber. Both ends have caps suitably sealed against external leakage, one containing the fluid port and the other the air intake valve and port. While a highly effective and efficient accumulator, this type has the disadvantage of high manufacturing cost as well as a limit in size to about three gallons maximum capacity. Packing leakage in many cases results in considerable amount of maintenance.

Bag Type Ideal for Unit Installations

Bag-separator accumulators, as shown in *Fig.* 7 were designed primarily to meet the requirements of low cost, high production, and trouble-free service brought about during World War II. Today, special emphasis is still placed on design simplicity, ease in manufacture, long life, and freedom from maintenance. As illustrated, this unit consists of a steel bottle or shell drawn from a single piece of special alloy steel without seams, welds or joints, carefully stress relieved and heat treated to withstand high loads. The alloy used is homogeneous throughout and is especially processed to provide a high factor of safety and permit a minimum of 20 per cent elongation for shock loading. If acids or other corrosive fluids are to be used in the hydraulic system, the inside of the shell is treated with a special plastic coating which will resist all corrosive action. The separator, *Fig.* 7, a fully closed synthetic rubber bag, is drawn into the shell through its wide mouth and is installed by means of two nuts screwed on the valve stem, which is molded to the rubber and fits into an opening in the other end of the shell.

Many years of research and development in rubber and methods of molding have resulted in a foolproof separator bag of exceedingly high wear resistance and long life, which also is impervious to most hydraulic fluid mediums. Special rubbers are available and bags are carried in stock for such fluids as castor oil, which affect the standard bag. Design and shape of the separator bag are such that volumetric efficiency over 90 per cent, with the accumulator mounted in any position, can be guaranteed. Experience in many thousands of installations, however, has shown consistent efficiencies around 97 per cent. Use of a bag automatically creates separate fluid and gas chambers eliminating the necessity of moving seals. The bag itself forms a permanent wall and makes cross leakage impossible, synthetic rubber developments having resulted in an extremely impenetrable bag, capable of withstanding operational temperatures from −40 F to 200 F.

Tests on a complete unit charged with air pressure to 1800 psi without any oil backup has shown absolutely no loss in air pressure while standing for sixty days. Further tests are proceeding to determine how long the unit can stand without air loss. Of course, their success is due in great part to the air valve which has been specially designed to take air loads from 8000 to 10,000 psi without leakage.

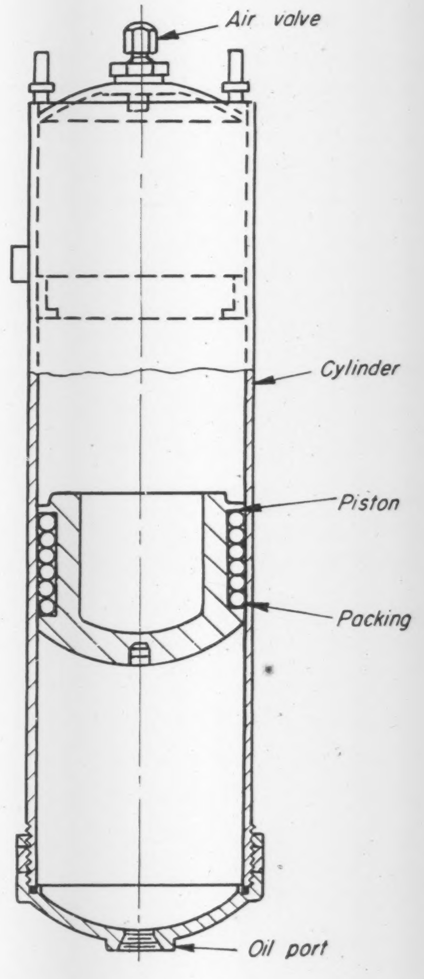


Fig. 6—Floating-piston accumulator employs O-rings or V-packings to seal the gas from the hydraulic fluid

Two types of plugs are used currently. The unit shown in *Fig. 7a* is a perforated plug with sufficient area to pass a normal flow of fluid without appreciable pressure drop. A new type plug, *Fig. 7b*, is rapidly replacing the perforated type and, as progress in development continues, will eventually render obsolete the perforated plug. The new plug has a large opening which permits fluid flow up to 50 gpm without noticeable pressure loss. As can be seen, this full-flow plug has necessitated the molding of a sealing button onto the heel of the bag to prevent extrusion. Current accelerated life tests, with the bag precharged at 1000 psi, carried out by rapidly cycling the accumulator from 3000 psi to zero have already passed all specification requirements. The plug is retained in the shell by a mating nut. A standard O-ring seal is used to prevent the possibility of external leakage.

Preloaded To Minimum System Requirements

Operating principle of the bag type accumulator is identical to that of the nonseparator type, and to place it in service it is preloaded with air or nitrogen under pressure (usually the lowest operating requirements of the circuit). Oil under pump pressure enters the accumulator through the oil port. The first drop of oil which enters the accumulator necessarily must displace an equal volume of air in the separator bag and, therefore, must enter at the preload pressure of the air chamber. As more oil is pumped into the shell, the air in the bladder is compressed further in such a way that the air pressure is always equal to the oil pressure, and the bag floats in equilibrium. Inasmuch as oil is, for practical purposes, incompressible, the air or nitrogen under pressure acts as a dynamic force to maintain oil pressure in the accumulator and to force it out when the system requirements call for it. A special safety feature has been incorporated in the Greer accumulator shown in *Fig.* 7, the shell being so designed that it will not burst at any pressure below four times the system operating pressure. However, the neck of the shell is designed so that when a pressure equal to three times the rated pressure is reached, the neck of the shell expands and the fluid leaks out. Thus, the accumulator is rendered absolutely burst-proof and the safety of equipment and operator is assured.

If applied correctly, the installation of an accumulator often will improve a hydraulic system. Most important, however, is the fact that the use of an accumulator makes it possible to develop greatly simplified systems of high efficiency and lower overall cost than is otherwise possible. Therefore, a study of the various applications is important and the hydraulic system designer, knowing these various applications, will have available a valuable tool for working out the best possible hydraulic system for his particular machine or mechanism. In Part II of this article, which will appear in the May issue of MACHINE DESIGN, the author will discuss the various methods of utilizing accumulators to advantage in hydraulic systems, their selection and positioning in the circuit, circuit simplification, and reduction of horsepower requirements.

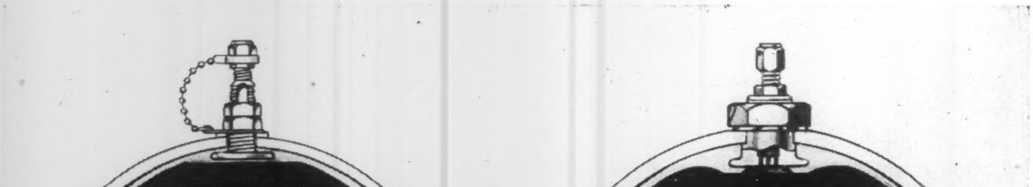
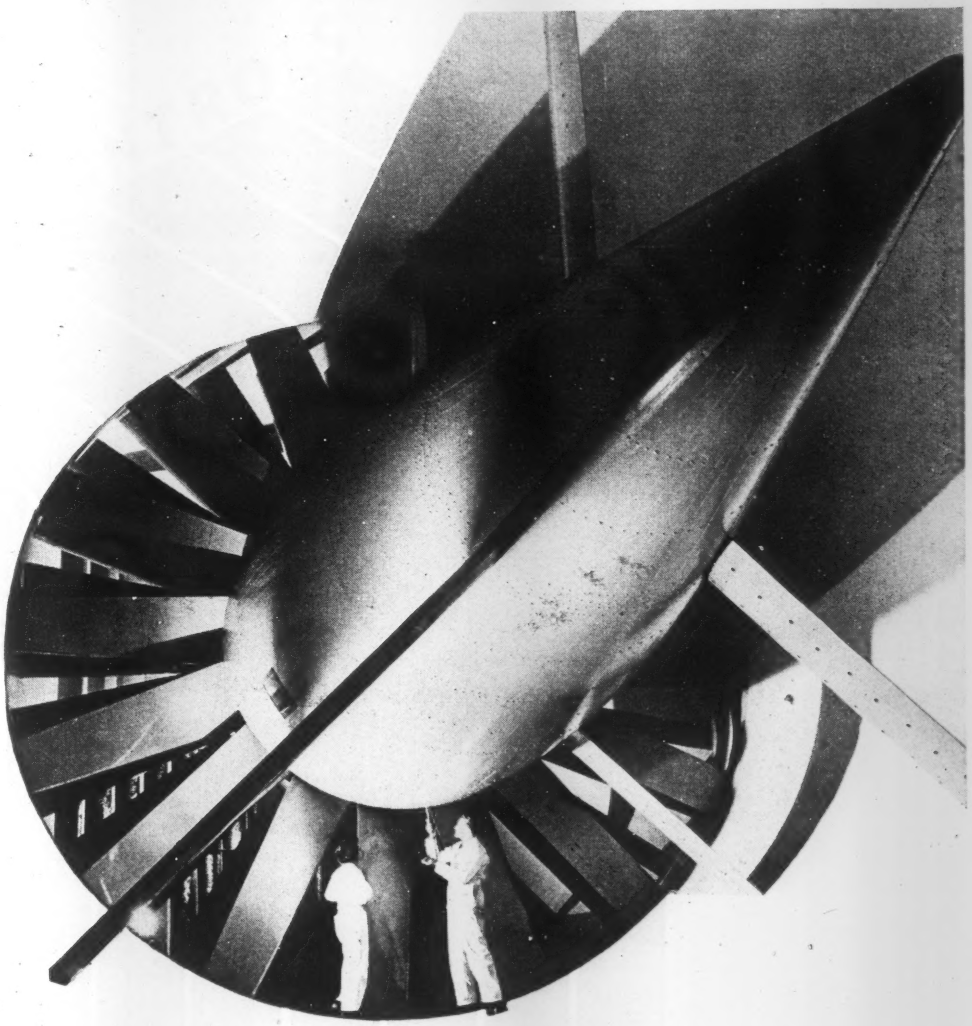


Fig. 7—Greer accumulator, utilizing a synthetic rubber bag separator, attains maximum simplicity and offers dependable service under all machine operating conditions. New type plug, b, left, is rapidly replacing older perforated type, a, extreme left



Eddy-Current Clutches for Variable-Speed Drives

By R. L. Jaeschke
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Dynamatic Corp., Kenosha, Wis.

DYNAMATIC type eddy-current clutches have proved advantageous in many applications as variable-speed drives, often making possible the elimination of gear trains, friction devices, etc., while providing infinite selective speed ranges. Although these clutches are primarily constant-torque devices, they can deliver momentary higher torques than the normal ratings. Their over-all efficiency is comparable to other constant and variable-speed drives but, as is the case with all constant-torque drives, efficiency drops off with speed. The difference in output speed and input speed must be dissipated as heat, which is carried away by venti-

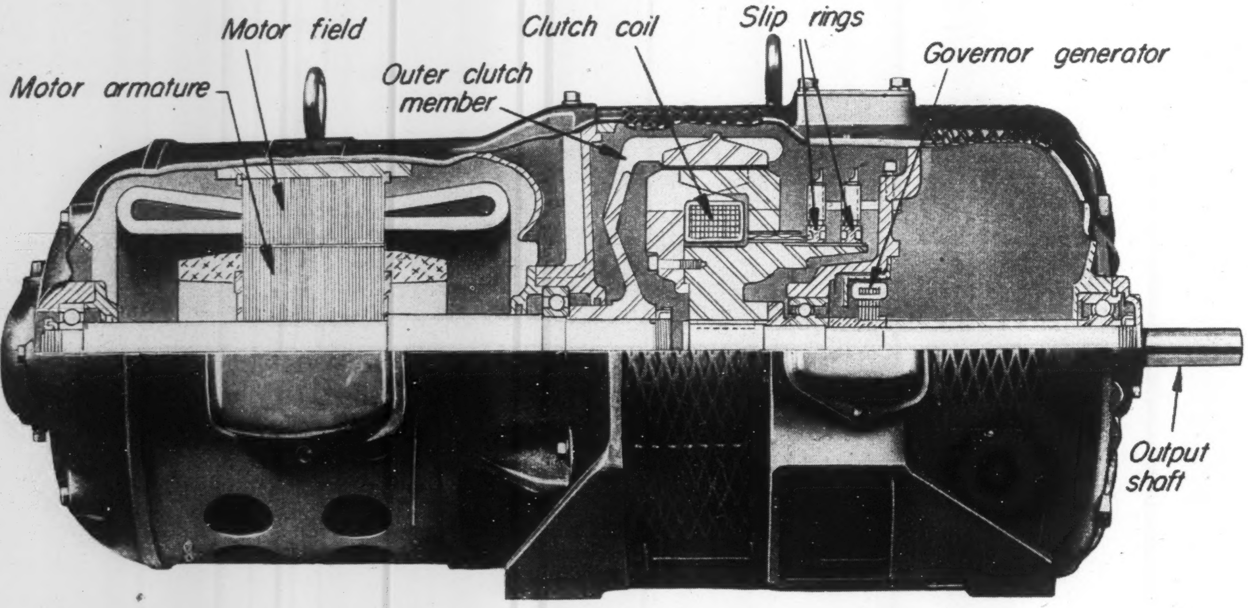


Fig. 1—Above—Cross section, with important units identified, of combination ac motor and adjustable magnetic clutch built as single unit

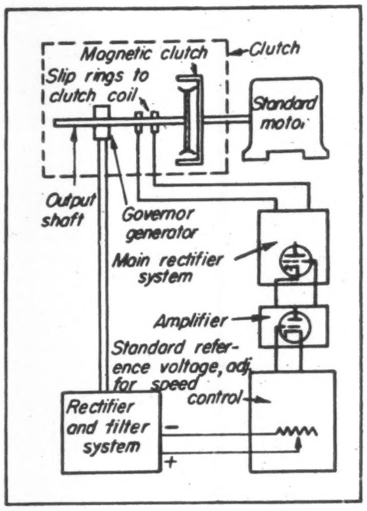

Magnetic clutch
Clutch
Slip rings to clutch coil
Standard motor
Output shaft
Governor generator
Main rectifier system
Amplifier
Standard reference voltage, adj. for speed control
Rectifier and filter system
−
+

Fig. 2 — Right — Block diagram illustrates relationship between important elements of an electronically controlled variable-speed drive, utilizing an eddy-current clutch

lation around the input member.

The cross section of *Fig.* 1 shows a typical eddy-current clutch and its driving motor. In the clutch, a toroidal coil is used for magnetic excitation. The magnetic flux is carried to the pole members located on the periphery of the coil-carrying member, the poles being so arranged that the magnetic flux follows the opposite magnetic potentials. A smooth drum surrounds the poles, being separated from them by an air gap of about 0.025-inch. This drum cuts the magnetic lines of force set up by the inner poled member, thereby generating eddy currents in the drum and creating a coupling between the two members capable of transmitting torque from the driving to the driven member.

Electronically controlling such a drive is extremely simple, since the amount of energy required for actual excitation is small—usually one-half of one per cent of the actual power transmitted. Electronically controlled drives of this type have already been applied in connection with wind tunnels (lead illustration), dynamometers, superchargers, and machine tool applications in sizes from ¼ to 18,000 hp, and speeds from 100 to 30,000 rpm.

A recent development in the field of industrial application is a punch press drive. By removing the normal flywheel from the punch press and replacing it with a Dynamatic combination field and armature, and providing a driven rotor of low inertia, it is possible to obtain the correct sequence of press operations with lower maintenance and at higher speeds. It is also possible to incorporate in the punch press a controlled-speed stroke, thereby eliminating in some cases the undesirable sine function stroke. This drive can be started and accelerated to full speed within from five to ten degrees of rotation with sufficient torque to drive the ram through the material.

Shown in *Fig.* 1 is a combination ac motor and adjustable magnetic clutch built as a single unit. Field of the motor is fixed in position. The armature of the motor and outer magnetic circuit of the clutch rotate as an integral unit at the fixed rate of the motor, while the output shaft and the inner part of the clutch (carrying the clutch coil and the slip rings for bringing dc energizing power to this coil) rotate at the desired output speed. Any set speed is maintained between the governor generator and the clutch-energizing electronic unit.

Clutch-motor combinations such as that described above usually are electronically controlled and are manufactured in standard sizes from one to seventy-five horsepower. A functional diagram of the component elements of a variable-speed drive is shown in *Fig.* 2. Driving power is supplied to the magnetic clutch by a standard motor. The output shaft of the clutch operates at some desired fraction of rotational speed, determined by the governor generator that sets the electronic control system which provides excitation for the clutch.

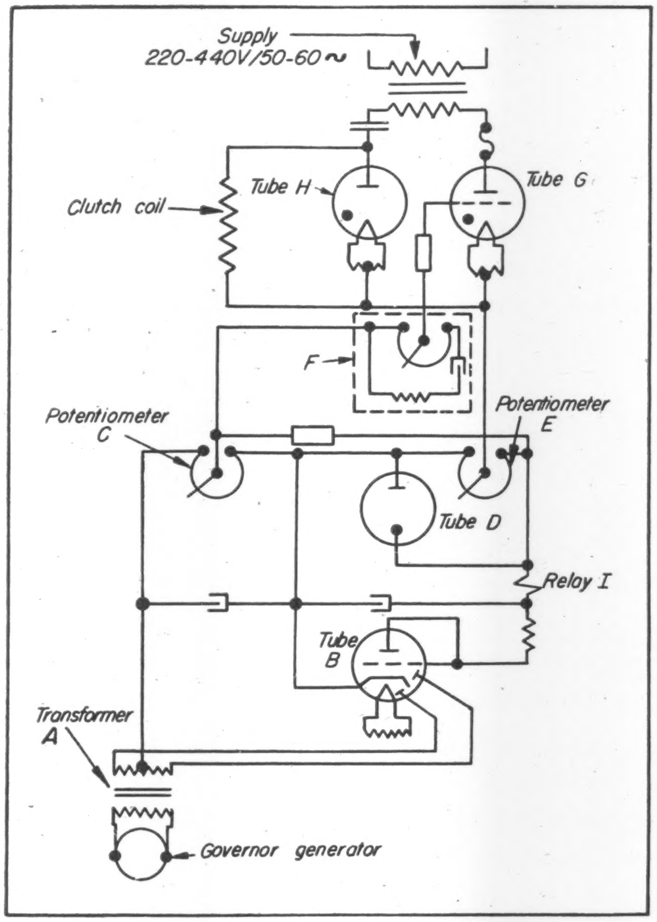


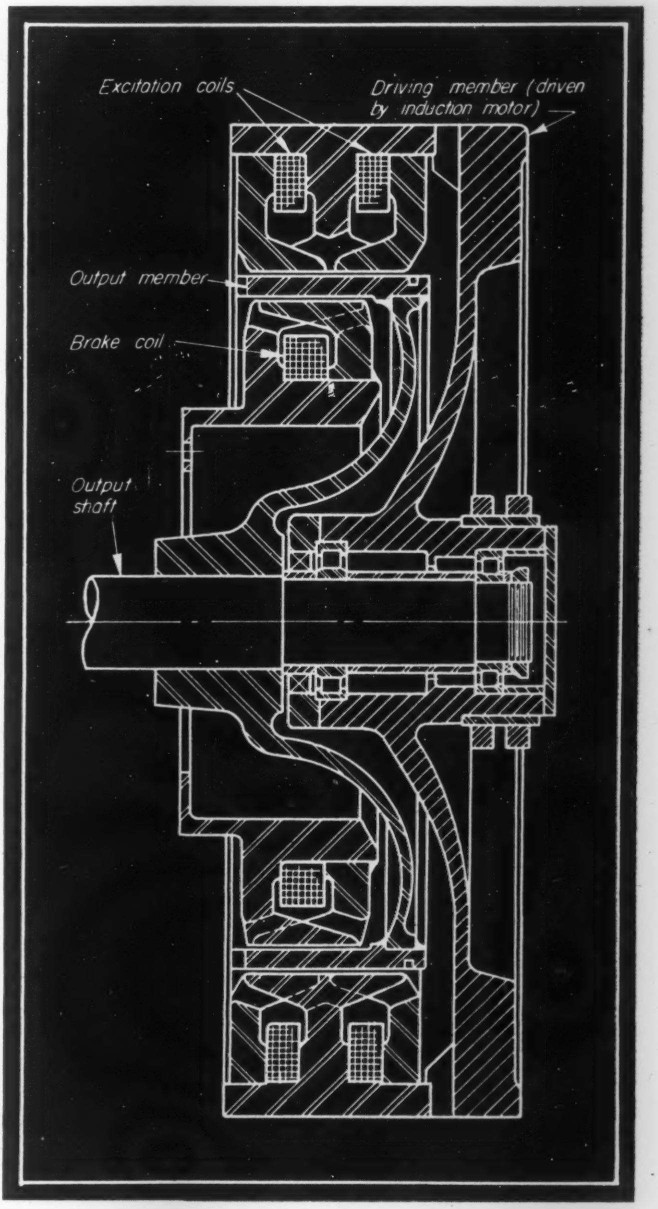
Fig. 3—Schematic diagram of standard electronic control circuit for variable-speed drive with eddy-current clutch

Success of the control mechanism depends upon: (1) The production by the governor generator of a voltage that is exactly proportional to speed of rotation of the output shaft; (2) an electronic control circuit that can be manually operated to adjust the speed to any desired value, but is entirely automatic and precise in regulation for any given setting of controlled speed; and (3) an electronically operated clutch mechanism responding to the resultant voltages from the manual speed control and the voltage from the governor generator. *Fig.* 3 shows a schematic diagram of the standard electronic control circuit with a horsepower range of five to seventy-five. The governor generator voltage, which is linear to speed, is fed into transformer *A*. The output voltage is ac with a frequency proportional to speed. This voltage then is rectified by the diodes of tube *D*. The voltage thus rectified appears across potentiometer *C*. Tube *B* also rectifies a low voltage and this voltage is regulated by tube *D*. A potentiometer, or voltage divider, *E*, is used as the speed-controlling medium, therefore the voltage developed from the governor generator across potentiometer *C* must be equal to that developed across any one setting of potentiometer *E* to effect speed control. The polarities of these two dc voltages are connected in series opposition. Should an increasing load slow down the output shaft, the governor generator will apply a decreasing voltage across *C*, thereby permitting the rectified voltage to apply a more positive potential to tube *G* and, at the same time, increase the current to the clutch coil. Tube *H* operates as a field discharge. This restores the original speed of the output shaft.

Circuit *F* is used to cause the current change into the clutch coil to be smooth, by modulating the current through the required range. The function of *F* is simple, since it applies an ac voltage to the grid 90 degrees out of phase with the plate voltage. This results in a "clipping" of the ac plate voltage, thereby varying the output control current smoothly from full-on to full-off.

Many objections have been raised regarding electronic-control tube life, protection against runaway, and tube heating time. Heating time for this electronic control is fifteen seconds, while the estimated tube life is approxi-

Fig. 4—Below—Driven member of this typical eddy-current clutch has low inertia, thus its acceleration from start to running speed is rapid



mately 4000 hours. Runaway protection in the event of a failure is eliminated to a considerable extent through the use of relay *I*. In important applications where shutdowns are dangerous, duplication of control equipment has been used as a safety precaution. A power plant, for example, requires extreme reliability, and in such cases spare electronic controls are used with electronic speed variance detectors so arranged as to transfer automatically from the defective control to the spare.

Electronic controls for these clutches have proved highly accurate as to speed control in actual service. It is possible to obtain as little as ten rpm variances from no load to full load, and also to maintain a running speed—despite line-voltage variations and small load changes—within three or four rpm of the set speed. It is also simple to connect variable-speed machines together so that several drives may be approximately synchronized, operating from one master speed controller.

Control of punch presses is relatively simple since the current is not modulated but is applied direct to either the brake or the clutch, by means of contactors. The driving member shown in *Fig.* 4 usually carries the excitation coils, has high inertia, and is driven by a small standard induction motor. The brake coil is carried on the braking member. The output member has low inertia and, as a result, acceleration time from standstill to speed is in the vicinity of 1/10-second. Time for braking is slightly longer. Since there are no rubbing parts there are no mechanical maintenance problems. The substitution of an eddy-current clutch for an air clutch on a press drive is simple since this clutch replaces the flywheel.

Demand for fractional-horsepower clutches has not been great until recently. A cross section drawing of a ½-horsepower clutch-brake combination is shown in *Fig.* 5. This drive has been used successfully in the machine tool industry for small grinders where relatively high speeds are required. In many cases several speeds are required from a single-speed motor drive. Previously, for this purpose, gears, belts and friction devices have been used. This practice resulted in a grinding pattern on the work caused by irregularities in either gears or belts. This difficulty is overcome by application of a magnetic clutch; no grinding pattern being perceptible on the work because there is no mechanical contact between the two active members, and the slight increases in speed caused by the driving gear or belt are absorbed in the clutch. In some cases electronic control is also applied to this type of machine, therefore a governor generator is required to actuate the control. Excitation for a clutch of the smaller size would not exceed 50 watts with a probable 25-watt minimum capacity.

Clutch Characteristics Suitable for Lathe Drives

There has been considerable controversy regarding the application of these clutches as lathe drives. Many engineers state that a lathe requires a constant horsepower drive even though gear changes are used. Many tests with motoring dynamometers for determining the horsepower required to drive a lathe have shown that constant torque with a minimum of three gear changes provides, on the average, sufficient power to operate almost any lathe. One lathe manufacturer incorporates this drive using a sectional speed-setting control so that one-third rotation of the dial equals the entire speed range. At each gear-changing point, an electrical switch is operated automatically, changing the gears in the head stock of the lathe. This will produce a smooth speed change with almost infinite ratio through the range of the lathe.

In some cases a "critical" occurs in a lathe between the tool and the work, or the tool and the bed of the lathe, or some other part, causing mechanical vibration to be set up in the entire machine. Since this critical occurs at resonance, vibration will take place only at some definite speed. Where it is possible to vary this speed slightly, the vibration can be eliminated, and this can easily be done with the Dynamatic electronic drive.

There are many modifications available for use with this variable-speed drive. Where electronic control is used, tachometers may be installed. Since the voltage from the governor generator is proportional to speed, these tachometers are merely voltmeters, calibrated in rpm. Torque-limiting circuits can be built into the electronic control so that the torque delivered by the motor is limited to a predetermined, adjustable, safe value.

Acceleration rates from standstill to maximum speeds also may be controlled through the use of condenser-resistor circuits. The motor-clutch combinations are so arranged that an eddy-current brake can be installed easily, and controlled by means of transfer of excitation.

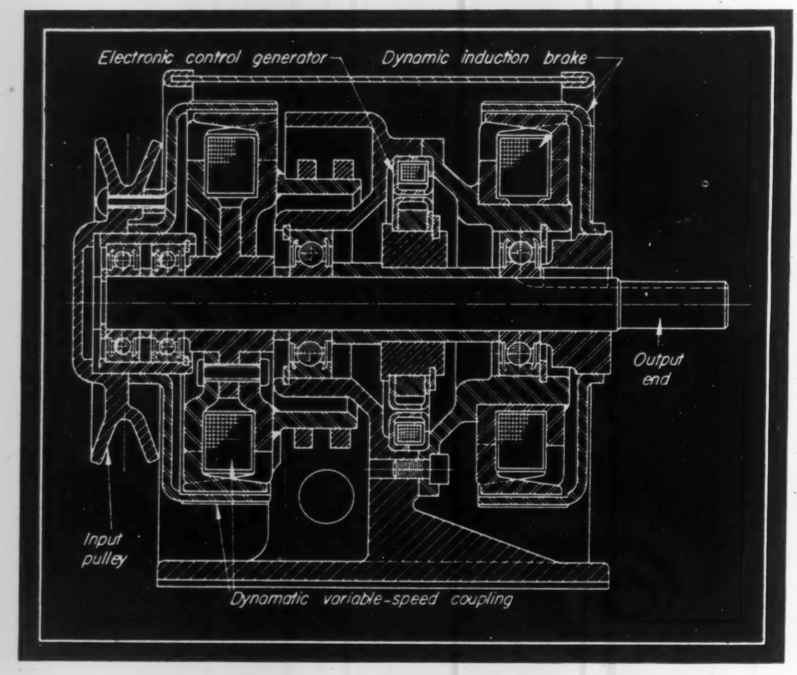
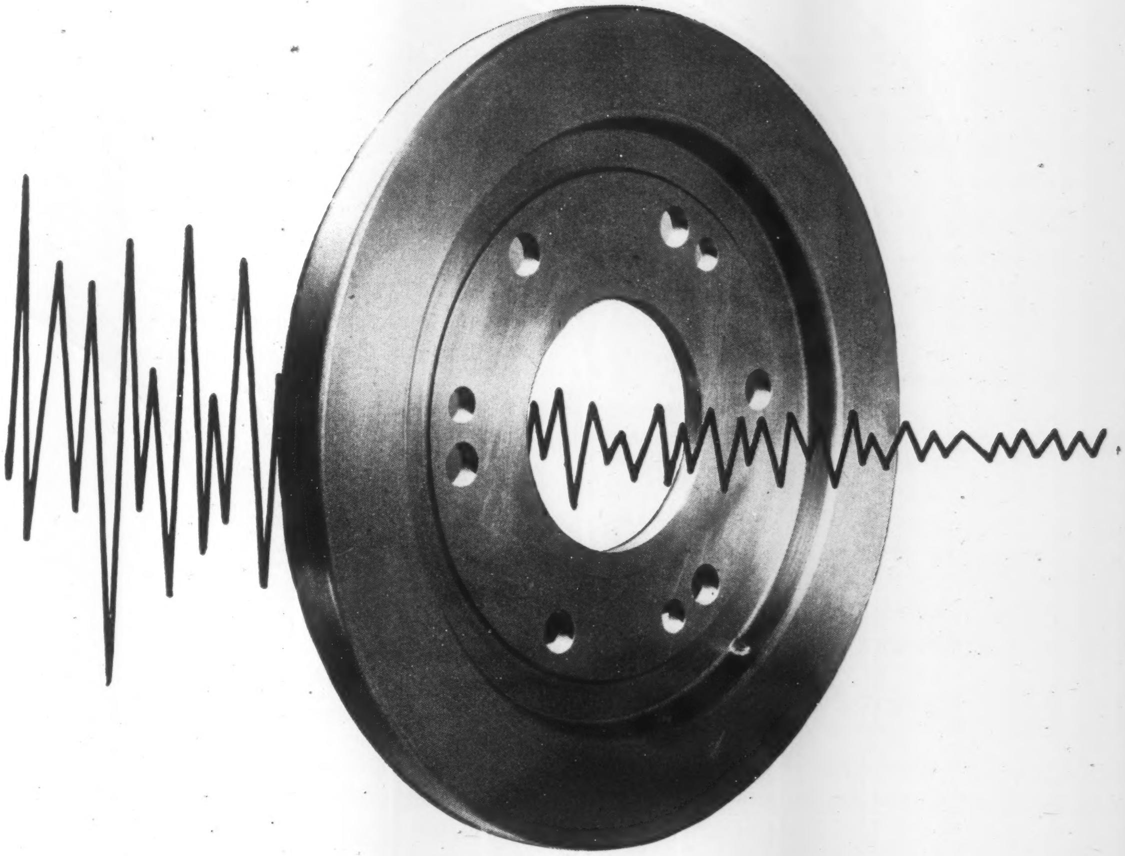

Electronic control generator
Dynamic induction brake
Output end
Input pulley
Dynamatic variable-speed coupling

Fig. 5—Arrangement of units in a ½-horsepower eddy-current clutch-brake combination as used for driving small grinders



Torsional Vibration Damper

Practical application of a viscous type damper utilizing silicone fluid as a medium

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BECAUSE of its mathematical adaptability, viscous damping has been extensively discussed in text books on dynamics, and its use proposed in connection with numerous theoretical developments for a number of years. Actually, however, its practical application has been quite limited until recently. The viscous torsional damper, with which this article is concerned, is an example of such applications.

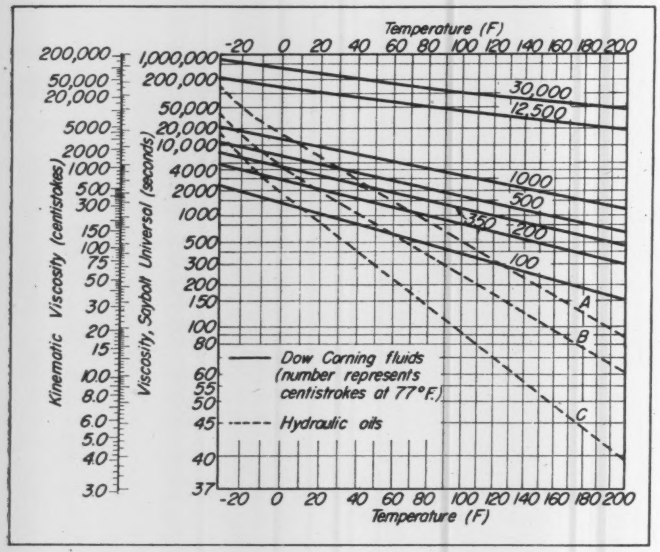
An understanding of the exact meaning of "viscous damping" may be obtained by the following considerations. If two surfaces are separated by a film of viscous fluid, the force necessary to move one surface with respect to the other is directly proportional to the area of the smaller surface, the relative velocity of the two surfaces, and the absolute viscosity of the fluid, and is inversely proportional to the thickness of the fluid film. Mathematically this resisting force may be expressed as $C(dx/dt)$ where C is a constant dependent on the area, the absolute viscosity of the fluid and the thickness of the fluid film, and dx/dt is the relative velocity between the two surfaces. This damping force, $C(dx/dt)$, of course, always opposes the relative motion.

Practically, the control of the surface areas and the distance between them presents no great difficulty. The difficulty arises in maintaining a constant value of the absolute viscosity. It is common knowledge that the viscosity of fluids decreases at a rapid rate with an increase in temperature. Since the resultant of a force acting over a distance is work—which in this case must be dissipated in the form of heat—it is seen that the absolute viscosity of a fluid in use as a viscous damping medium will change as the damper performs its function. Another but not so well known property of many viscous fluids is the decrease in absolute viscosity with an increase in rate of shear. In general, this effect becomes more noticeable as viscosities increase and limits the upper range of viscosities for which the mathematical ideal and the real are in sufficiently close agreement.

Temperature Changes Should Not Affect Operation

For the successful use of viscous damping in a specific application it is necessary that the inherent characteristics of the system be such that the change in damping due to temperature change will not prevent attainment of the desired result. The high viscosity, superior temperature-viscosity relationship, and excellent stability of some of the silicone fluids suggested their use in viscous damping applications where other substances had failed. Viscosity-temperature slopes of several silicone fluids are shown in *Fig.* 1, from which it is seen the characteristics show marked improvement over other known substances. The change in viscosity with change in temperature, however, is still of considerable magnitude.

Fig. 1—Viscosity-temperature slopes of silicone fluids compared with typical hydraulic oils



Untuned dampers with dry friction damping have been used for a number of years as a means of controlling the torsional vibration of internal combustion engine crankshafts. For the damper proportions in general use, an untuned damper with viscous damping is, in theory, somewhat more efficient than the untuned damper with dry friction damping when the damping for each is optimum. Optimum damping for the dry friction damper is dependent upon the amplitude of vibration which in turn is dependent on the damping and work input. This is not the case for viscous damping where the optimum value of the damping constant C is a function only of the constant parameters of the system.

Damper Is of Simple Construction

Shown in *Fig.* 2 is a viscous torsional vibration damper recently developed to take advantage of the unique properties of silicone fluids. It consists of a light-weight two-piece welded housing which encloses an annular space containing a loosely fitting ring which functions as an inertia mass or flywheel. Clearance between the flywheel ring and the housing is filled with the viscous fluid. The housing is rigidly attached to the shaft whose vibrations are to be damped and, in operation, drags the flywheel ring around with it through viscous action. Although it assumes the average speed of the housing, the flywheel responds only slightly to torsional vibrations of the shaft, and the resulting periodic differences in speed cause a viscous drag on the housing which always opposes the vibration and effectively dampens or retards it.

Extensive mathematical study of the viscous torsional vibration damper as applied to the crankshaft of an internal combustion engine, as well as the specific means of applying the theory to a given engine, is given in Reference 1[*]. To illustrate the basic behavior of a system incorporating an untuned damper with viscous damping, the system shown in *Fig.* 3 has been chosen because of its mathematical adaptability. Actually much more complicated systems may be idealized in this form with little loss of accuracy. A method of reducing a multimass system to the equivalent of *Fig.* 3 is developed in Reference 1, Page 97. Referring to *Fig.* 3,

I_a = Moment of inertia of damper mass

I = Moment of inertia of main mass of the system to be damped

K = Torque necessary to twist the shaft through a unit angle

C = Damping constant, already defined, which in this case is the force necessary to rotate the mass I_a at unit velocity with respect to the mass I

ϕ = Angular deflection of the mass I at any time t

ϕ_a = Angular deflection of the damper mass I_a at any time t

$M_o \sin \omega t$ = Harmonically varying moment applied at mass I

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[*] References are listed at end of article.

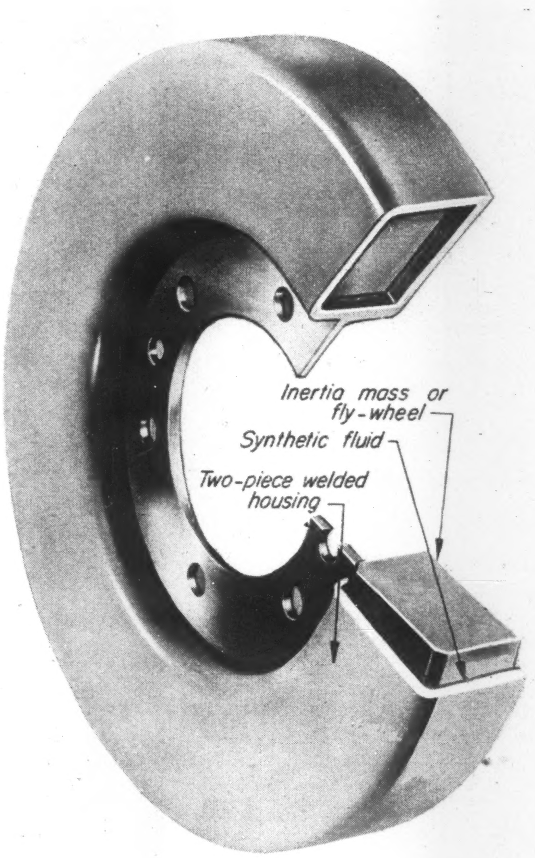


Fig. 2—Construction of Houdaille viscous torsional vibration damper, which utilizes silicone fluid hermetically sealed, with flywheel ring, into welded housing

ω = Forced frequency = 2π times the vibrations per second.

The equations of motion are

$$I\frac{d^2\phi}{dt^2}+K\phi+C\left(\frac{d\phi}{dt}-\frac{d\phi_a}{dt}\right)=M_0 \sin \omega t \tag{1}$$

and

$$I_a\frac{d^2\phi_a}{dt^2}+C\left(\frac{d\phi_a}{dt}-\frac{d\phi}{dt}\right)=0 \tag{2}$$

The steady state solution of these equations is

$$\phi_0=M_0\sqrt{\frac{(-I_a\omega^2)^2+(\omega C)^2}{[(-I\omega^2+K)(-I_a\omega^2)]^2+(\omega C)^2(-I\omega^2+K-I_a\omega^2)^2}} \tag{3}$$

where ϕ_o is the maximum amplitude of vibration of the mass I.

The forced frequency, ω, appears in this equation and its value for a maximum value of ϕ_o is an unknown. However, if

μ = Mass ratio = I_a/I

ω_n = Natural frequency of the undamped system = $\sqrt{K/I}$

ϕ_{st} = Static angular deflection of the mass I when acted upon by the moment M_o

then, as shown in Reference 2, for optimum damping the maximum value of ϕ_o/ϕ_{st} occurs when

$$\frac{\omega}{\omega_n}=\sqrt{\frac{2}{2+\mu}} \tag{4}$$

and the value of ϕ_o/ϕ_{st} at this point is

$$\frac{\phi_0}{\phi_{st}}=1+\frac{2}{\mu} \tag{5}$$

The value of optimum damping, from Reference 1, is

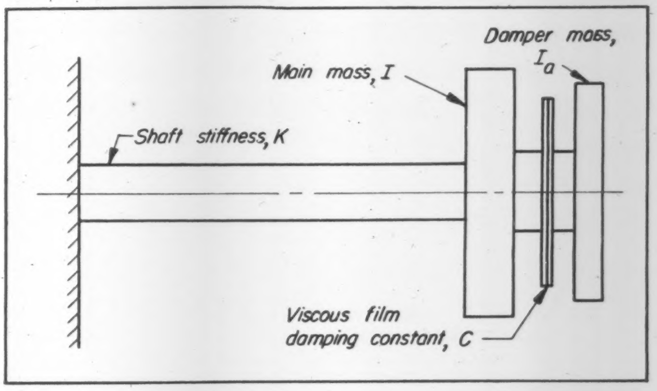
$$C=\frac{2I_a\omega_n}{\sqrt{2(1+\mu)(2+\mu)}} \tag{6}$$

A solution of the problem for optimum damping does not constitute a practical solution unless it can be shown that the value of the damping constant C is not critical. The solution of Equations 1 and 2 for ϕ_o/ϕ_{st} when C is other than optimum, as obtained by the author in Reference 1, tends toward inelegance, which probably explains its nonappearance in previous literature.

Results obtained are shown in dimensionless form in *Fig.* 4, where ϕ/ϕ_{st} is the maximum ratio of amplitude to static deflection, as the forced frequency ω varies from zero to infinity; μ as before is the damper mass over the main system mass, and C/C_c is the damping constant over $2I_a\,\omega_m$. *Fig.* 4 indicates that the value of C is not critical.

To clarify the application of the fluid characteristics of *Fig.* 1 to the system characteristics of *Fig.* 4, it may be remarked that the kinematic viscosities shown on *Fig.* 1 are equal to the absolute viscosity if the specific gravity of the fluid is unity. The specific gravity of 30,000-centistoke silicone fluid is very nearly unity at 77 F. These viscosities were, however, determined at extremely low rates of shear so they do not necessarily indicate the absolute viscosity at the relatively high rates of shear encountered in many practical applications. Measurement of absolute viscosities at relatively high rates of shear is extremely difficult because of localized heat. Tests con-

Fig. 3—Simplified torsional system used in developing the theory of the viscous rotary damper



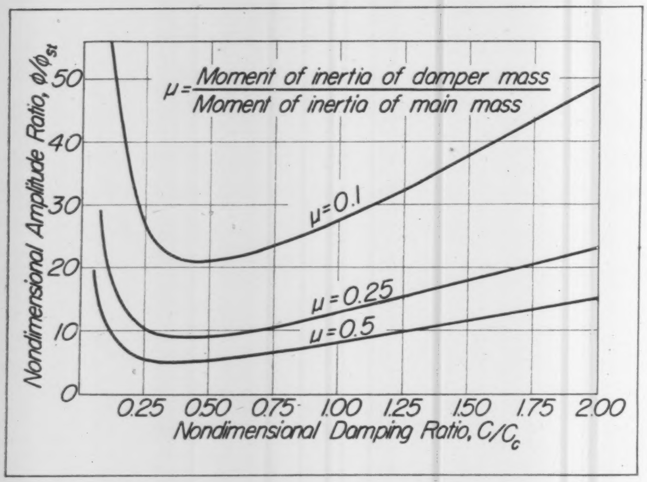


Fig. 4—Variation of vibration amplitude with damping, for three different ratios of absorber mass to main mass

ducted at Houde indicate that a 30,000-centistoke silicone fluid at 77 F at a shear rate of 1200 reciprocal seconds (velocity/film thickness) has an absolute viscosity equal to at least 85 per cent of the kinematic viscosity taken from *Fig.* 1; at 0 F, however, this has dropped to less than 50 per cent. This effect is beneficial in extending the efficient operating range of the device.

MULTICYLINDER ENGINE APPLICATION: In applying the theory to a multicylinder engine, it is first necessary to idealize the engine to a relatively simple mass-elastic system. The method of doing this is explained in numerous texts on vibration (Ref. 2). The end result is a system of inertias coupled through torsional springs. The next step is to find the natural frequency of the simplified system. This is rather easily accomplished by means of Holzer's method which also gives the relative amplitudes. From the Holzer table the stress at any point in the system as a function of amplitude at the location of the damper may be determined and from this the allowable amplitude at the location of the damper is established. The moment of inertia of the damper necessary to maintain this amplitude may be determined from the equation

$$I_a = \frac{2I_e W_t}{\pi \omega_n^2 I_e \phi^2 - W_t} \quad \text{(7)}$$

where

ϕ = Amplitude at the damper
I_a = Moment of inertia of the damper mass
I_e = $I_1\phi_1^2 + I_2\phi_2^2 + \ldots + I_m\phi_m^2$
The values of I and ϕ being taken from the Holzer table. The value of I at the location of the damper should include all masses at that location except I_a. The value of ϕ at the location of the damper must be unity.
W_t = $W_{in} - W_h$
W_{in} = Work input per cycle of vibration when the amplitude at the damper is ϕ
W_h = Work dissipated by inherent engine damping when the amplitude at the damper is ϕ. Evaluation of W_{in} and W_h is rather complex and the reader is referred to an excellent treatment of the subject by Den Hartog in Reference 2. For reliable values of the gas torque harmonics involved, Porter's curves in Reference 3 are recommended.
ω_n = Natural frequency of the undamped system as taken from the Holzer table.

The damping constant C may be taken as

$$C = I_a \sqrt{\frac{2\omega_n^2}{2 + (I_a/I_e)}} \quad \text{(8)}$$

The foregoing approximate solution was developed by the author in Reference 1 and compared with a rigorous solution, the results being in excellent agreement. Rigorous solution, even when inherent damping is neglected, is too cumbersome for practical use but was carried out as a check of the approximate method. It also serves as an illustration of the effect of the damper at points other than that of maximum amplitude, and of the performance with values of damping other than optimum. In *Fig.* 5 is shown the plotted result of the rigorous solution for the mass-elastic system of a typical six-cylinder automotive engine with sixth-order gas torque excitation, inherent engine damping being neglected. Amplitudes shown are those at the location of the front cylinder. Several values of the damping constant C have been included. Optimum value is that which produces a curve with a horizontal tangent through the common point.

In general, the agreement between calculated values of amplitude and measurements taken in the field has been very good. Application of the damper to auxiliary shafts and equipment has also met with success.

Free and Self-Excited Vibrations

OTHER APPLICATIONS: Although the discussion has been directed at the case of resonant forced vibration there are two other important types for which the application of viscous damping is beneficial, namely, free and self-excited vibrations. If operating temperatures are uniform or if a considerable change in damping is not detrimental, viscous damping may be applied directly as hydraulic or friction dampers are applied. A free damper mass such as the crankshaft damper or a damper mass connected through a spring offer distinct advantages in numerous cases, inasmuch as a change in viscosity does not alter the characteristics of the system nearly so much. The presence of the damper does not alter the response of the system to transient forces except by increasing the inertia of the system by a percentage of the damper mass inertia. The damper is a simple foolproof device which can be used where a connection to ground is impractical or impossible such as the application to a rotating shaft or the wing tip of an airplane.

Effect of the untuned damper on free vibrations may be found by solving Equations 1 and 2 with $M_o \sin \omega t$ equal zero. A solution for a system with an undamped natural frequency of $\omega_n = \sqrt{3000}$ is shown in *Fig.* 6,

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which is self-explanatory. Again it is seen that the damping constant is not critical.

A self-excited vibration may be defined as a free vibration with negative damping.

If the term $M_0 \sin \omega t$ in Equation 1 is replaced by $Q(d\phi/dt)$ the system of *Fig.* 3 becomes unstable without the viscous damper. If displaced from its equilibrium position it will continue to oscillate with ever-increasing amplitude.

Origin of the term $Q(d\phi/dt)$ is usually rather obscure and will not be discussed here. However, its existence is evidenced by numerous cases of self-excited vibration. It can be demonstrated mathematically that if $M_0 \sin \omega t$ is replaced by $Q(d\phi/dt)$ in Equation 1 the system represented by Equations 1 and 2 is stable if the damper mass, I_a, has a minimum value of

$$I_a = \frac{Q^2}{K} + 2Q\sqrt{\frac{I}{K}} \quad \text{.......................} (9)$$

The required value of the damping constant C is

$$C = \frac{A \pm \sqrt{A^2 - 4B}}{2} \quad \text{.......................} (10)$$

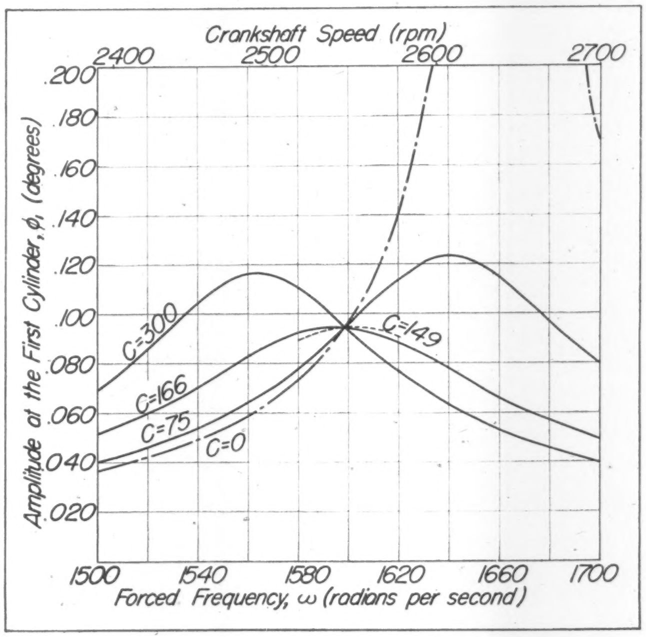
where

$$A = \frac{I_a^2K + I_aQ^2}{(I+I_a)Q}$$

and

$$B = \frac{I_a^2K}{I+I_a}$$

Fig. 5—Curves showing vibration amplitude at first cylinder of typical six-cylinder automotive engine due to sixth-order gas-torque harmonic, for various values of the damping constant "C". Damper inertia is 62.5 per cent of effective inertia at each crankpin



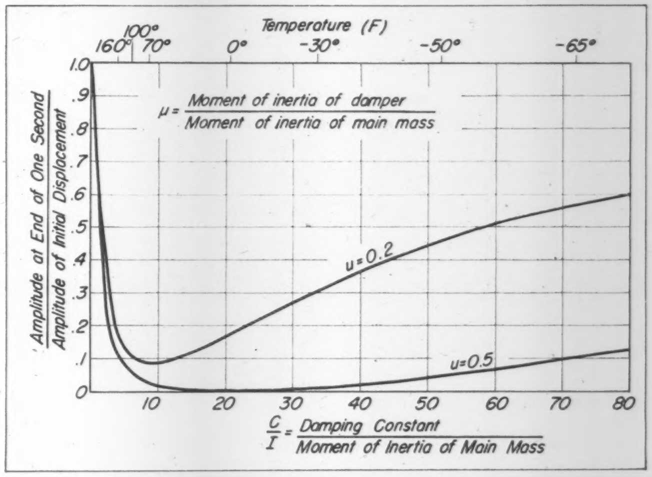


Fig. 6—Effect of damping constant, C, on amplitude of free vibration after one second, for system having undamped frequency of 8.72 cycles per second. Being directly proportional to absolute viscosity of fluid, C varies with temperature as shown on scale at top of chart

If the minimum value of I_a from Equation 9 is used, C will be single valued. However, if I_a is made somewhat greater than the minimum value, C will have two real positive values and the system will be stable for all values of C which fall between the two values obtained from Equation 1. The spread between the minimum and maximum values of C is found to increase rapidly for a small increase of I_a over the minimum value.

Damping Requirements Not Critical

CONCLUSION: It has been shown that the attachment of an auxiliary mass to the main mass of a system through the medium of a viscous film is an effective method of damping a system whether the vibration is forced, free, or self-excited. In all cases the amount of damping required is not critical and the fluids available are such that they meet the damping requirements.

Certain advantages of this type of damping might suggest its use where other types are applicable. In cases where it is impossible or impractical to attach a conventional damping device to a satisfactory reaction member the floating-mass approach presents a dependable and simple solution to the problem.

Greater efficiencies may be obtained in some cases by coupling the auxiliary mass to the main mass through both a spring and a viscous film. It is also possible to damp a torsional mode and a linear mode of vibration at the same time with a single auxiliary mass. The new fluids make possible a simple and dependable solution to a great variety of previously unsolved or partially solved problems.

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Actuator Employs Friction Drive

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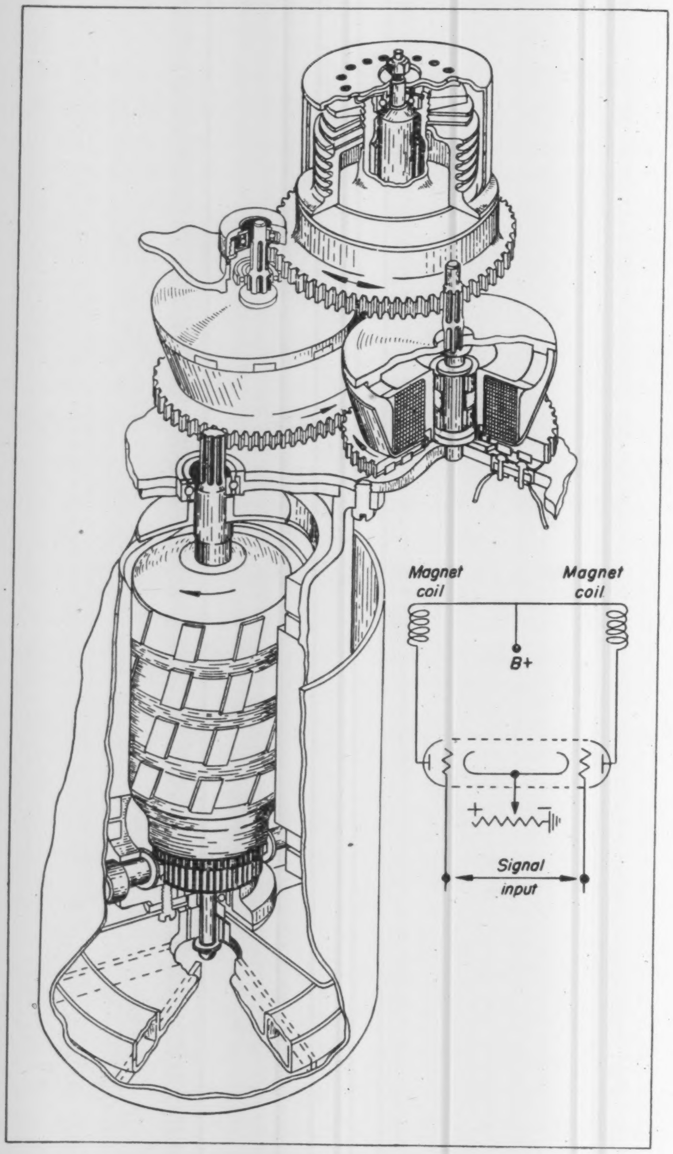
FINAL drive to the elevator, rudder and ailerons of aircraft controlled by the C-2 automatic pilot is through a unique servo actuator employing a friction drive. Developed by engineers of Lear Inc. in conjunction with the equipment laboratory of the Air Technical Service Command, the unit is characterized by a high torque-to-inertia ratio and high sensitivity, coupled with light weight and compactness.

Shown schematically in the accompanying drawing, the Lear servo actuator is, in effect, an electromagnetic friction drive comprising two continuously driven, conical electromagnets geared together so as to rotate at the same speed but in opposite directions. Poles of these magnets consist of two smooth, annular surfaces, concentric with the axis of rotation. Two disks, geared to a common output member, complete the magnetic circuit between the two annular poles of each magnet, so that when the magnet coils are energized large attractive forces are developed due to intimate contact between surfaces.



Inasmuch as the friction torques transmitted from the rotating magnets oppose each other, the direction of rotation of the output shaft is determined by the magnet having the greatest excitation. A notable feature is the absence of change from static to kinetic friction when the output shaft rotates. This is because the disks are, at all times, in sliding contact with the magnet poles, and unequal excitations of the magnet coils merely change the rate of slipping, decreasing the rate for the disk on the magnet having the greater excitation, while increasing it for the other.

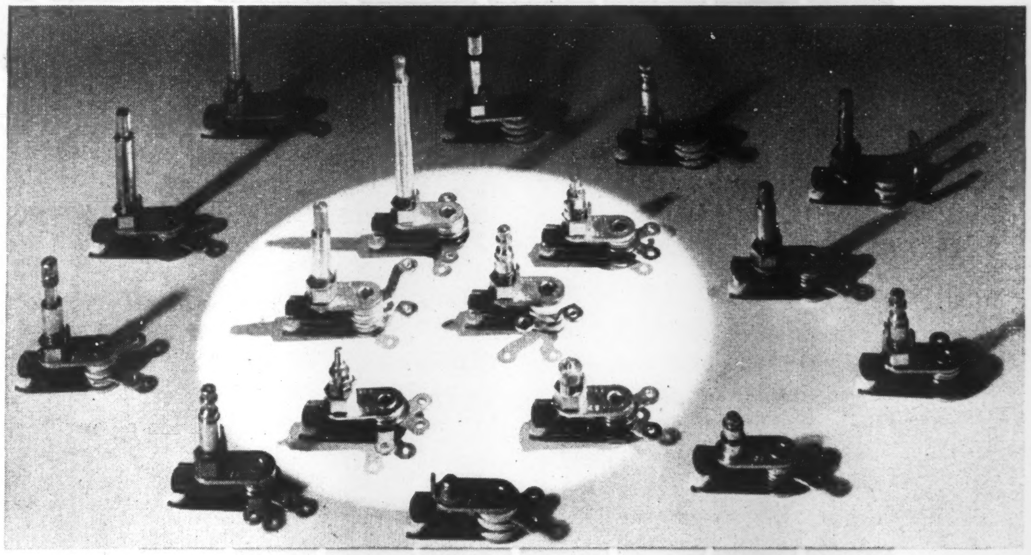
Special Alloys Reduce Wear

As a result of extensive metallurgical research, special alloys have been developed which, when appropriately heat treated, have made it possible to overcome the common objection to friction drives—short life because of wear. Generation of heat in the drive constitutes no problem, as the power dissipation is negligible, and the heat is rapidly carried away from the sliding surfaces due to the absence of any insulating layer of friction material.

When the output of the servo drive is intermittent, as in the case of regulator action or positioning control, the size of the motor can be reduced greatly by the addition of a small flywheel which, in the automatic pilot application, is combined with a cooling fan. Power for the servo drive may be derived from any suitable rotating member of more or less constant speed. However, for most self-contained servo drives, an electric motor is the natural choice. Pneumatic turbines and hydraulic motors have been considered for certain specialized applications.

Excitation of the magnets is usually, but not necessarily, controlled through an electronic circuit such as shown in the drawing. The two magnet coils of the friction drive are connected in the plate circuits of a balanced push-pull amplifier, the grid excitation of which may be obtained from any suitable pick-off or signal source.

In the C-2 automatic pilot application an ac generator winding has been included in the rotor of the dc motor, so that the latter also fulfills the function of an inverter, delivering the ac voltages required for the error detectors and the sense-detecting rectifiers, as well as for the rectified B-supply. Thus the entire system is dependent upon only a single power source—in this case 28 volts dc. An ac power supply can be used equally well.



Thermal Controls

Their location, range and frequency of operation have important effects on performance

By W. C. Stevens
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NOW that some of the rush to get into production has quieted down, design engineers have a chance to study details of their machines in a more thorough manner. In some cases, the machines were new to the manufacturer and not too much was known about actual performance requirements. However, manufacturers now have had experience under current manufacturing conditions and are able to study possible changes to obtain a better design at a lower unit cost. Today, the trend is for machines to be as nearly automatic as possible.

On a majority of machines thermal control appears to be involved one way or

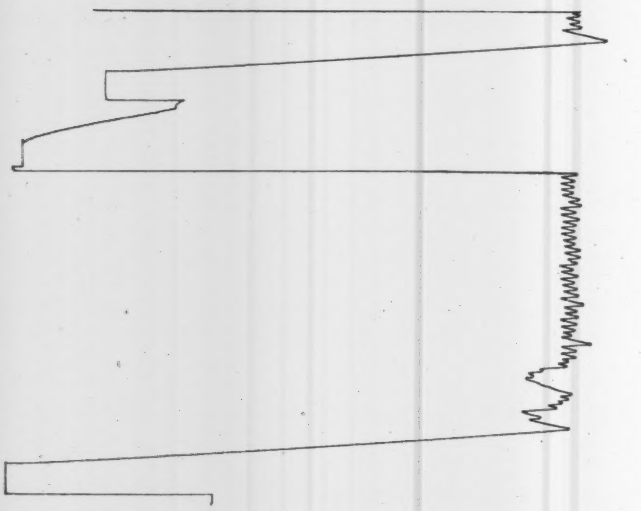


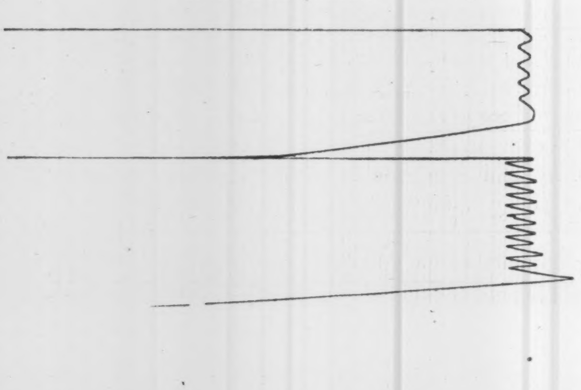
Fig. 1—Irregularity of heating was caused by thermostat contacts which were fastened poorly to current carrying members. The bimetal carried the current and the heat generated caused extra operations of the thermostat

another. It is not restricted to the control of temperatures alone but covers other forms of control as well. For instance, there is protection against burning out of elements of liquid heaters in case the unit runs dry. There is also the case of protecting motors against burn-out due to overload conditions.

While machines are being studied with the idea of making changes, there is an excellent chance to analyze the thermal protection characteristics of these machines with the idea of making improvements. An actual case recently involved a machine that had been exceptionally well designed with one exception. The thermostat had simply been ordered "from a catalog". The result was a delay of months in starting real production. A few machines were actually made under pressure and their cost was tremendous. In addition, those that were put out in the field came back. This was costly, both from a repair cost standpoint and from a dealer and user reaction standpoint.

Contrary to some claims, there is no one thermostat that will perform equally as well on all applications. Some designs of thermostats have wider applications than others. However, one that performs exceptionally well in one machine might perform only fairly well in another and be a total failure as a protective device on a motor or in a circuit requiring a contactor coil. Likewise, a thermostat that handles 15 amperes on 115 volts ac satisfactorily may be a failure on applications where it is required to handle one ampere on a 12-volt ac circuit. Sometimes lower voltages and currents require a change in contact material as well as contact construction.

Fig. 2—Actual bimetal temperature of thermostat is shown (top curve) compared to temperature measured on surface of heated platen



Temperature Range Is Important

Another important point involves selection of the bimetal used for the thermal-responsive element. Certainly the bimetal used on a 170 F thermostat for controlling the temperature of a water tank would be unsatisfactory for an ironer with a range up to 550 F.

Some thought should be given to the fact as to whether or not an adjustable thermostat is required. If the machine can use a nonadjustable thermostat, it is simpler to operate. One more thing for the operator to adjust is eliminated and field service due to abuse or improper setting is obviated.

Operating curves shown in *Figs.* 1 to 6 illustrate some of the conditions found on machines. For *Figs.* 2, 4, 5 and 6, thermostats similar to those shown in the head illustration were used. Vertical scale on the Leeds & Northrup Co. charts is 10 minutes for each division. Some of the captions explain briefly the causes and how the trouble was corrected. This does not mean that a majority of machines on the market today operate in this manner but merely indicates the situations that can occur without proper testing and careful selection of a thermostat for its application.

A natural question then is, "How should I handle my thermal control problem?" Unfortunately, that question cannot be answered completely here or in any other one article. It involves many details of application and construction.

One of the first steps should be to determine what the actual requirements of the machine are. These are obtained from

1. Field reports, if it is an old design
2. Published reports or tests on competitive apparatus, if it is a new design.

For instance, if plus or minus 10 F control will satisfy field requirements, by no means should a thermostat be employed that will control within plus or minus 2 F.

Operations Limit Life

It is fundamental that the closer the temperature control of the machine, the more frequent will the thermostat have to "break and make" the circuit with definite wattage conditions. It is also fundamental that under a given set of operation conditions there are only so many makes and breaks in the life of a pair of contacts. Obviously, the more frequently the contacts operate, the shorter the thermostat life.

Some thermostats are designed to give extremely close temperature control on a device and, accordingly, will operate more frequently than will others. The rate at which the thermostat opens and closes the contacts can also be varied by the mounting of the thermostat. It is desirable to mount the thermostat in such a way that it is quickly affected by any changes in the temperature of the machine and yet not close enough to the heat source to give artificial operations, resulting in premature failure.

Once the actual control requirements are determined, one or two of the thermal control manufacturers who have had experience in making thermostats for machines of the particular type that is to be built should be consulted. In confidence they should be shown the details of the machine, told what the machine is expected to do and asked to make recommendations. If possible, they should have the machine in their laboratory to equip it with a thermostat, to run tests on it and then to submit the machine with test reports.

Pilot Runs Are Advisable

Then this machine should be tested to be sure that it gives the desired operating results. Before jumping into production in tens of thousands, a pilot run of fifteen to twenty machines should possibly be made, depending on the cost of making up the samples. From these some field operation and test operation data of great value may be obtained.

While laboratory tests are essential, they cannot replace actual field tests. If an ironer is being manufactured, for instance, in addition to running laboratory tests and putting samples out in homes of people who do a normal amount of laundry, some samples should be placed in a commercial laundry where they will get more use in one day than they would in the average home in a month. Likewise, if a vulcanizer is being built, some should be put on life test in the busiest filling station that can be found, rather than in some neighborhood station that seldom fixes a "flat".

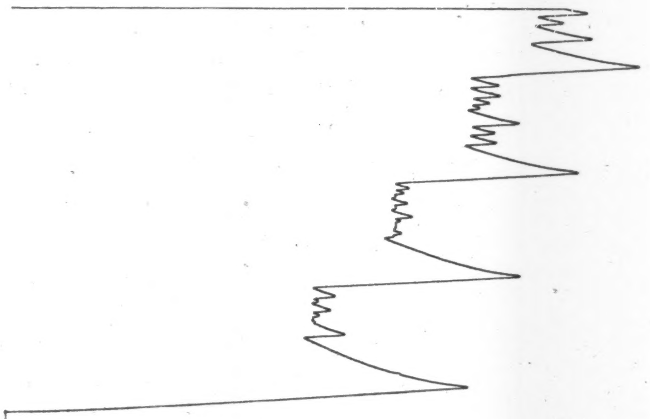


Fig. 3—Heating up curve of a machine using an adjustable thermostat of a poor design. The bimetal was not able to follow the temperature of the machine as shown by extreme amount of overshoot. Thermostat bimetal and springs were held together loosely

Periodically, these machines should be brought into the laboratory and checked to see if there has been any change in operation. It would also be a good idea to periodically replace these machines with similar ones from current production. In that way, a continuous check on the performance of current production is available. If any trouble develops, it will be possible to correct it before too many of the machines get in the field.

When it is felt that the thermal control is operating satisfactorily, the element problem should be investigated before releasing tools for production. This does not imply that the element design should be neglected until this stage of design but there has been a tendency of manufacturers to use wattage as high as they possibly can. The idea is splendid provided the machine actually needs it and provided the control will handle higher wattage. A study of the machine should be made as to what field requirements are going to be. Then the wattage may be adjusted accordingly.

For instance, if wattage can be reduced from twelve hundred to one thousand watts and still give the same production, a better factor of safety is obtained for the element design, resulting in longer element life. On the other hand, it may result in the machine taking slightly longer to heat to operating temperature. This may or may not be objectionable.

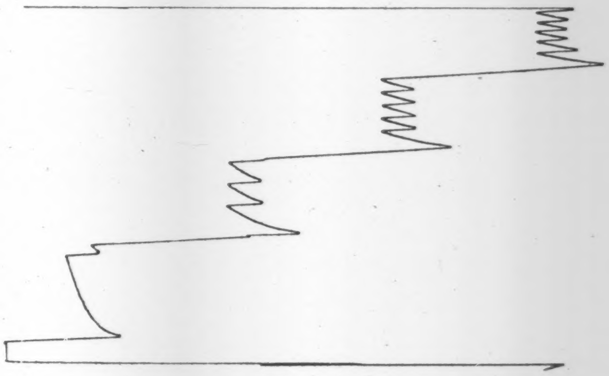


Fig. 4—This curve was run on the same machine as in Fig. 3 after improving the thermostat mounting and substituting a better designed thermostat

There are some applications which are required for periodic use where the machine must heat up rapidly and then maintain exceptionally close temperature control. Such an application is a crystal oven on radio transmitters. The manufacturers have solved the problem by using two heater circuits and two thermostats. One thermostat is connected to the so-called heating up or "roughing" element and is set to cut out at 65 F. This heats the device quickly to 65 F and, as is expected with any machine heating up rapidly, there is some overshoot on the initial heating period. A second thermostat is designed to open at 70 F and maintains the temperature of the oven at this temperature. The wattage in this particular circuit is just enough to provide radiation losses under waste conditions. The result in the combination is a very rapid heating up and then a leveling off and maintaining of a temperature at a close limit.

In another application, the designer connected permanently part of the heating element circuit in parallel with the motor circuit so that when the machine was started, part of the heaters were thrown on the line. There was not enough wattage to cause any trouble if left on indefinitely, as long as the rest of the machine was operating. The thermostat was required to handle only a part of the wattage, resulting in lower rating and longer life.

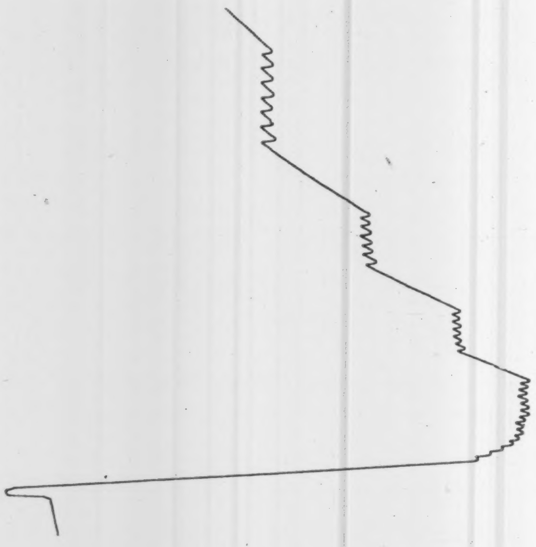
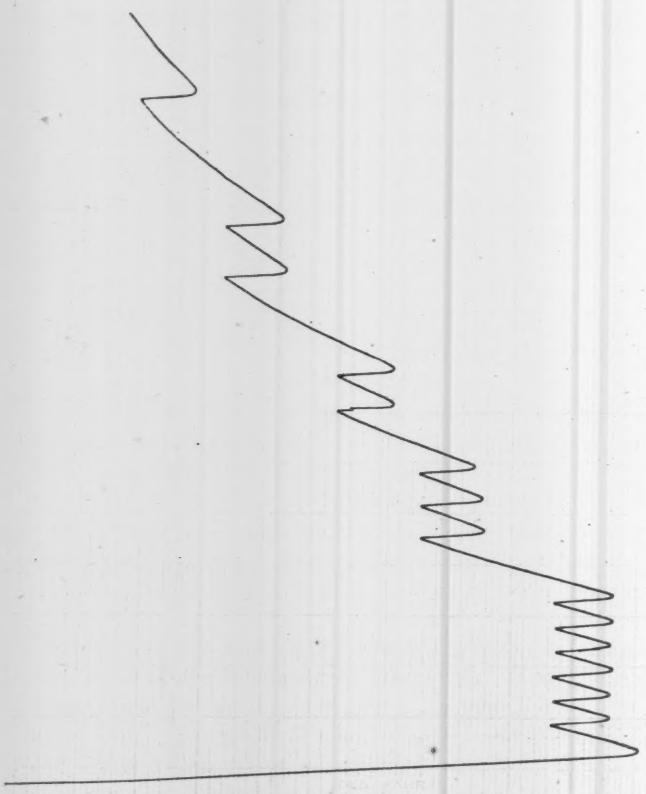


Fig. 5—Above—Heating up curve for an ironer for various heating positions. Thermostat design and mounting were excellent but the heating element was so arranged that heat was radiated from the element to the bimetal. Thus the bimetal could not closely follow the temperature rise

Fig.6—Below—Same machine and same thermostat used in Fig. 5 gave these results when the radiant heat trouble was corrected. The same settings gave higher temperatures



In selecting a thermostat for a machine, if at all possible, the thermostat should be calibrated completely and ready to put in the machine when received. Also, it is desirable to have this thermostat calibrated in such a manner that, if anyone attempts to change the calibration in the field, the tampering would be evident. The reason for this is there are many "basement mechanics" who like to repair apparatus and many service stations throughout the country which can not be familiar with all the requirements of every machine. Furthermore, they frequently are not equipped to make temperature checks. If something happens to the device and they try to repair it, they will not get the thermostat properly adjusted for satisfactory operation. In the long run, the manufacturer of the machine will be blamed. As a precaution, a completely calibrated thermostat is preferable. This also simplifies service problems in that service stations throughout the country will have thermostats available that can be set easily into the machine.

Obtaining Underwriters' Approval

If a machine will require Underwriters' approval, before accepting the thermostat, it will be well to make a check with the Underwriters to be sure that the machine design as well as the thermostat construction are satisfactory for approval. It is impossible at this time to get approval from the Underwriters on a thermostat as a unit unless it is a self-contained unit. The average thermostat that is built into a machine cannot be approved by the Underwriters owing to the fact that it would be possible to fit it into a machine without sufficient clearance. If at all possible, the machine should be taken to the Underwriters to discuss the entire construction with their engineers. Frequently, they can help make modifications that would eliminate possible field troubles, saving much time in the long run.

The same is true if machines are to be shipped into Canada. In that case, the thermostat and the machine will have to be approved by the Canadian Standard Association, which is similar to the Underwriters Association. Their specifications are not the same as those of Underwriters. Equipment approved by Underwriters may or may not pass the Canadian Standard Association.

Both of these associations would be glad to give manufacturing specifications for use in designing a machine and, if there are any problems in connection with these specifications that are not clear, they are ready to assist in making modifications of the machine to fit their requirements.

Summarizing the situation then, before thermostats for use in a machine are definitely decided upon, they should be tested thoroughly in the machine. A thermostat is not necessarily satisfactory just because the price is low or because it fits into the machine assembly. Performance in the final analysis is the test of design.

Drives and Controls Offer Key to Progress

It is doubtful whether any other phase in the development of machines is demanding more attention from designers at the present time than the proper application of drives and controls. The lightning-like rapidity with which new developments continue to occur in this field provides the alert designer with ample opportunity for wide choice in the selection of the most suitable equipment for his purpose.

One of the primary reasons for the enhanced interest in drives and controls is the need for, and the increasing trend toward, the utilization of all forms of variable-speed drives. Insofar as numerous types of production machines are concerned, the variable-speed drive has proved particularly adaptable in that it permits precise control for production under the most favorable conditions. Furthermore, it facilitates the making of abnormally high increases in machine speed in many cases where these are found practicable due to improvements in tools, fixtures or other auxiliary equipment.

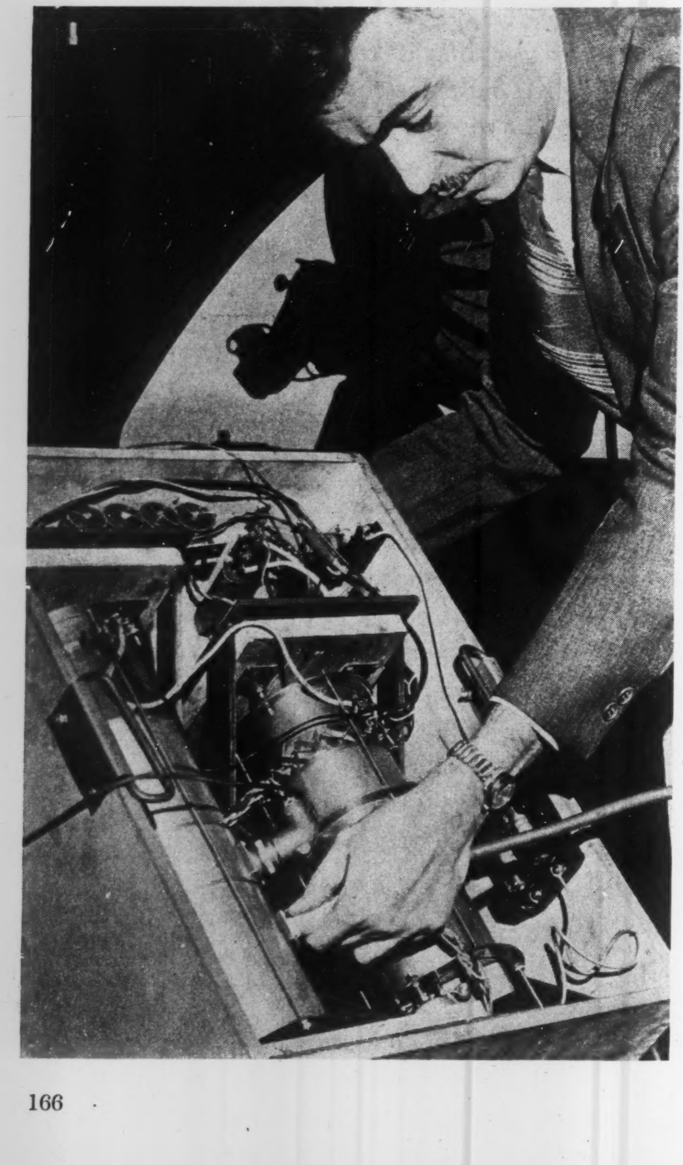
On other types of machines also the variable-speed drive—mechanical, electrical and hydraulic—is gaining in popularity. One of the most recent noteworthy examples is the use of hydraulic torque converters for driving the rear wheels of the new Tucker automobile. Passenger car designers in this country have been engaged in studying the possibilities of drives of this nature for some time but this is the first commercial application that thus far has come to light. Considering the many advances that have taken place in automobile transmissions over recent years, much credit is due the designers of the new car in going ahead with this radically different drive.

Another reason for the current interest in drives and controls is the possibility of widening the outstanding applications of electronics that already have been made to machines. Many of these applications have been discussed in earlier issues of this journal and several are treated in articles in this particular number. From control of motor speed to control of intricate computing mechanisms, the new science offers as wide a range of potentialities as can readily be imagined. It is safe to say that during the next few years many of the current concepts of design of machines will be overthrown by further developments in the electronics field and by successful application of electronic equipment by progressive designers.

L. E. Jermy

Scanning THE FIELD for Ideas

Capable of tracking rockets speeding at approximately 3800 mph, the telemetering system illustrated below automatically transmits 28 items of information every 1/35-second, including measurements of acceleration, position of control vanes, and fuel pressure as well as data on rocket-skin temperature. All this information is received at the ground station and recorded on film.

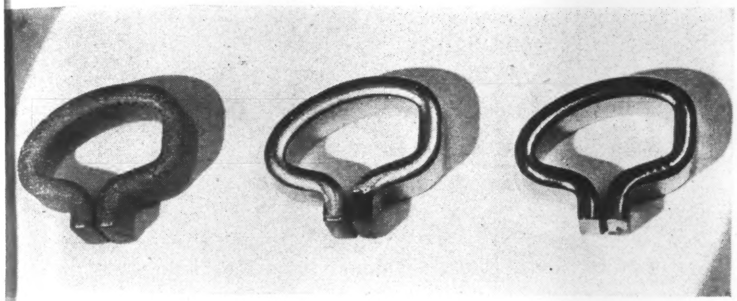


Weighing only 15 pounds, less than one-sixth the weight of previous telemetering devices, this General Electric system uses only ten electronic tubes. The missile-borne transmitter is packaged in two 4-inch diameter pressurized cans, 12 and 15 inches long. Power is supplied by a 28-volt battery, weighing 12 pounds.

Each of the quantities to be recorded is converted to a voltage varying from zero to five volts which is fed to one segment of a stationary commutator having 28 channels. Each quantity is transmitted as pulse-width modulation. At the receiving station a linear sweep on one cathode-ray oscilloscope is triggered by the leading edge of each received pulse. The incoming signal is shown as a line whose length is proportional to the quantity being measured.

Electroplating by periodic reverse-current method produces a plate that is considerably smoother than the surface of the material to which it is applied. The technique reduces finishing costs by 20 per cent or more and gives a plating fully equal to that produced by conventional methods. Reversals of current during the plating process remove surplus or unsound metal, level peaks and "polish" the deposit. Greater plating speed is obtained mainly because stronger current can be used in the plating portion of the cycle and, since the metal surface is brightened by current reversals, hand buffing or polishing can be reduced or eliminated.

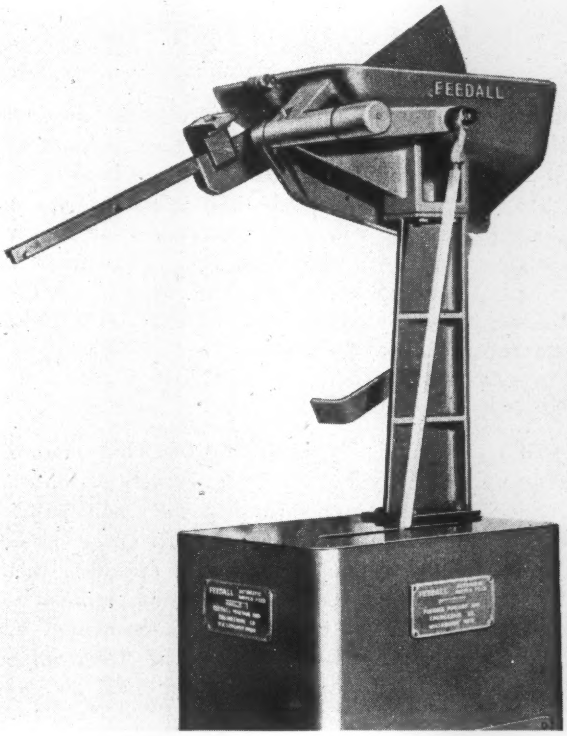
The new process, developed at Westinghouse Electric Corp., works better with some electrolytes than with others. Plating baths best suited for its use are the cyanide-type baths such as copper, silver, zinc, cadmium and even gold. In general,

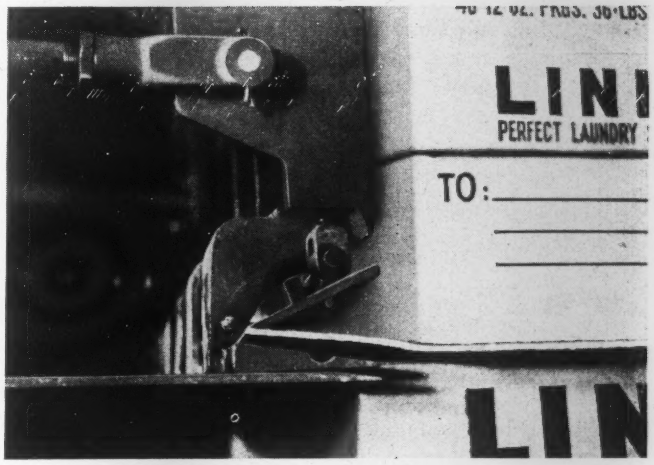


improvement is evident in most acid and alkaline electrolytes. Shown in the illustration above are three magnets plated by different methods in the same solution, none of them being polished. All received about the same amount of copper plate. Magnet at left was direct-current rack plated for five hours, the one in the middle was direct-current barrel plated for seven hours, and the one at the right was periodic reverse-current plated for four hours.

Feeding mechanism, below, designed as a machine auxiliary, readily converts a semiautomatic into a fully automatic machine. Drive is by crank link from a power unit in the base, consisting of motor on adjustable slide, variable-speed V-belt pulley and gear reducer with crank arm. Link connecting crank to feed mechanism is adjustable in length for various conditions of feeding and is fitted with Heim spherical bearings, simplifying alignment and obviating complicated linkage. Damage to drive or to parts being fed is prevented by utilization of a spring-tensioned overload release on the hopper drive, so designed that if a jam should free itself the release will engage again in proper position.

Hopper consists of two castings with a spacer between, thickness of spacer depending on size of part to be fed. Likewise, the oscillating pick-up blade is built up to the desired thickness and bolted to a cast arm on the hopper driveshaft. Pedestal height and feed-chute length in this hopper feeder developed by Feedall Machine and Engineering Co. are determined by application requirements. Type of parts fed are either cylindrical or headed.





Push-pull attachment on lift truck, above, effects a simplified method of handling loads mounted on carrier sheets instead of conventional pallets. Developed by Clark Tructractor, a division of Clark Equipment Co., the unit utilizes a hydraulically actuated gripper device for clamping an extended margin of the carrier sheet and pulling the sheet and load onto the carrier plate. At destination the load is lifted and registered over the area. Then a hydraulic pusher device, working against the load, deposits the cargo as the backing truck withdraws the carrier plate.

Assets to a Bookcase

Finishing Metal Products

By H. R. Simonds, consulting engineer, and Adolph Bregman, consulting engineer and secretary Masters Electroplating Assoc.; published by McGraw-Hill Book Co. Inc., New York; 352 pages, 5¾ by 8½ inches, clothbound; available through MACHINE DESIGN, *$3.50 postpaid.*

Decorative finishing of metal parts is a subject which has vastly increased in importance in the last decade. It is now highly desirable that the designer familarize himself with the complete field of finishes, and know their limitations and advantages for all applications he may meet.

This book, the second edition of a compilation of data from the field of machine finishes, is a welcome addition to the sparse literature on this subject. Not only does it discuss the properties and variations of the many finishes, but it gives in sufficient detail to satisfy the designer, a discussion of the application technique. He may thus appraise the inherent limitations of specific types of finish.

Starting with a discussion of the commercial aspects of appearance and finish, the book follows through the subjects of metal preparation, polishing and buffing, plating and spraying, metal coloring, organic finishes and porcelain enamel. Material is presented in a readable manner, is amply illustrated and appears well suited to the demand for information on methods of enhancing the market values of consumer machines.

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Precision Hole Location

By J. Robert Moore; published by the Moore Special Tool Co., Bridgeport, Conn.; 448 pages, 7⅜ by 10⅝ inches, clothbound; available through MACHINE DESIGN, *$3.00 postpaid.*

In any branch of engineering it is important that the designer be fully acquainted with the manufacturing methods by which his creation is to take form. This is particularly true with relation to the precise forms of manufacturing where tolerances run to less than one-thousandth of an inch. For those particularly concerned with hole forming and location, this book is an excellent reference text giving in clear language a complete discussion of the art.

As a summary of hole forming and locating practice, production problems, and historical background, it can well be said that this is an outstanding accomplishment. Exceedingly well prepared, the book has numerous fine illustrations—drawings, diagrams and photographs. One-hundred-eighty-four pages at the rear of the book are devoted to tables intended to simplify the location of holes. For circles of holes arranged in groups from two to one hundred, the table gives base-circle factors, for locating hole centers from normal tangents to the circle.

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Trademark Act of 1946

By H. A. Toulmin, Jr., attorney; published by The W. H. Anderson Co., Cincinnati; 200 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$5.00 postpaid.*

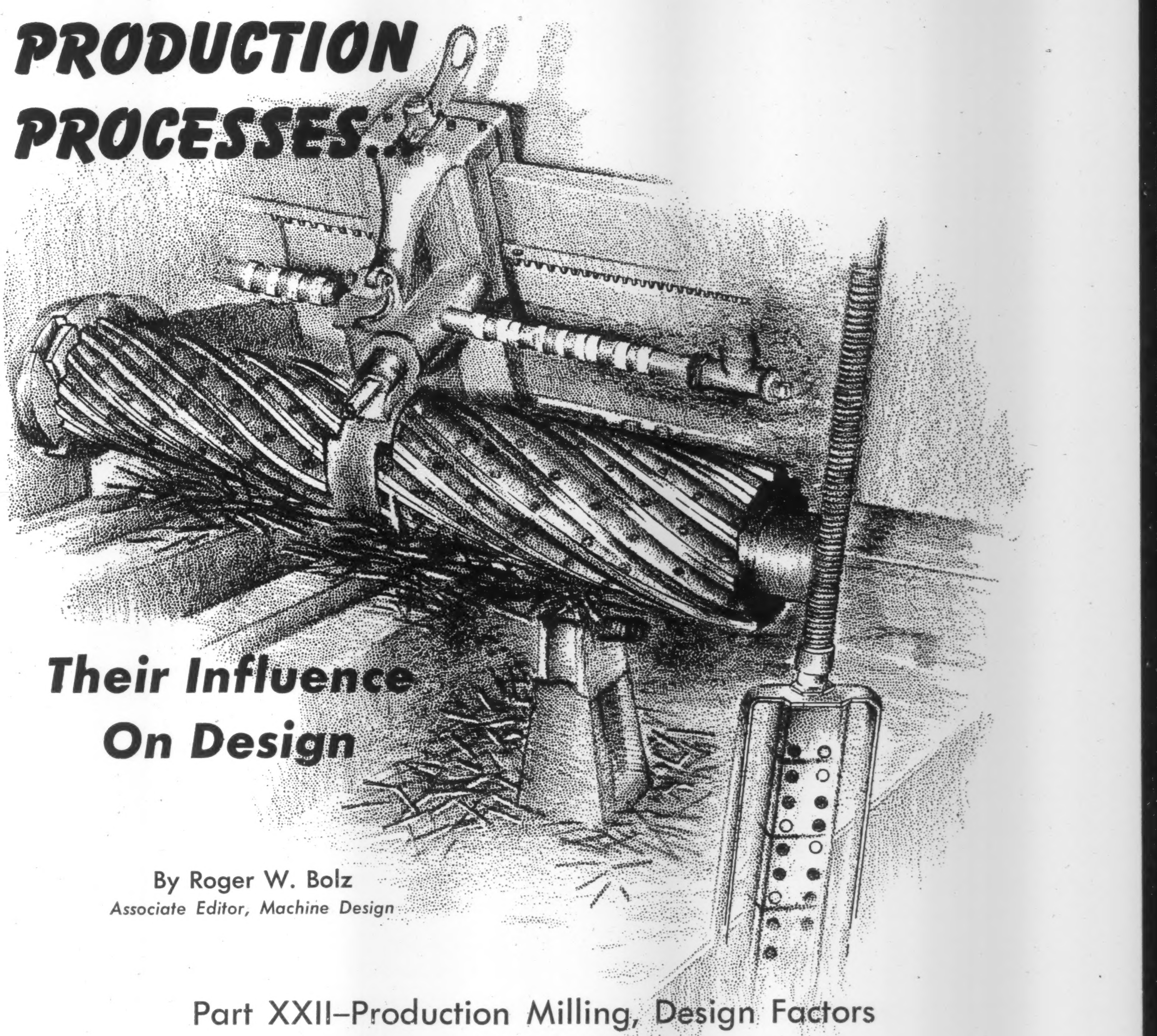
The Lanham trademark act of 1946, effective July, 1947, places in one law all federal statutes relating to trademarks and repeals all prior laws inconsistent with the new act. It is, therefore, quite likely to affect most of the manufacturing organizations of this country.

This book analyzes the provisions of the act and discusses in some detail the meaning and ramifications of the law. Included are discussions of the purpose of the act, functions under the act, and a comparison of the procedure under the new and old acts. Among the most useful sections of the book is a division giving questions and answers, several pages of which are devoted to typical questions such as the effect of the law on the status of old trademarks. An entire chapter is devoted to an outline of what a trademark owner should do immediately in order to comply with the new law. The book offers to each owner a means of obtaining a copy of the rules and regulations of the act immediately upon issuance by the Commissioner of Patents.

Catalog of American Standards, an index and price list of publications and standards of the American Standards Association, is now available. This 23-page booklet lists publications relating to standards used in most of the engineering fields, among which are mechanical, automotive, transportation, electrical and chemical. Measuring 7¾ by 10⅝ inches, the booklet, paper bound, may be obtained from the American Standards Association, 70 East 45th St., New York 17, free of charge.

Revised standards for general drafting-room reference have been published by The American Society of Mechanical Engineers. The paperbound, 8 by 10½-inch, 53-page booklet bears the title "American Standard Drawings and Drafting Room Practice" and deals with approved methods of drawing arrangement, covering such typical subjects as views, lines, screw threads and dimensioning. The publication is available at $1.25 from The American Society of Mechanical Engineers, 29 West 39th St., New York.

PRODUCTION PROCESSES...



Their Influence On Design

By Roger W. Bolz
Associate Editor, Machine Design

Part XXII–Production Milling, Design Factors

MANUFACTURE of machine members to suit specific theoretical or calculated design requirements often, and justifiably, will require specially developed production equipment. This holds true with milling as well as with the various other basic methods for processing parts. As a rule, however, such parts are usually special (as well as the machine into which they are assembled), quantities are small or design limitations so critical that changes are impossible or unreasonable.

Quantity production, on the other hand, to be as economical as possible, dictates maximum simplicity in the design of parts, minimum number of processing operations, maximum ease of holding, locating and clamping, etc. With parts to be milled, this would indicate design for face or plain milling wherever possible. In addition, design should be such that the maximum number of surfaces can be milled at one pass. It is well to remember that once a part is in the fixture, it takes no more production time to mill three or four surfaces than it does for one so long as the miller used can carry the cutters, ***Fig.* 20**. Again, clamping and reclamping of a part is a likely source of errors, consequently accurately related surfaces are most easily produced at one setting.

Keeping in mind the problems incident to practical fixture design—rapid loading, accurate easy locating, solid clamping without cutter interference, etc., will assist materially in reducing many of the production problems commonly encountered. Elimination of difficult, hard-to-reach, complex surfaces wherever possible as well as all slow operations will help to achieve the economy of production so necessary to produce low-cost parts.

To insure advantages of optimum metal removal rate

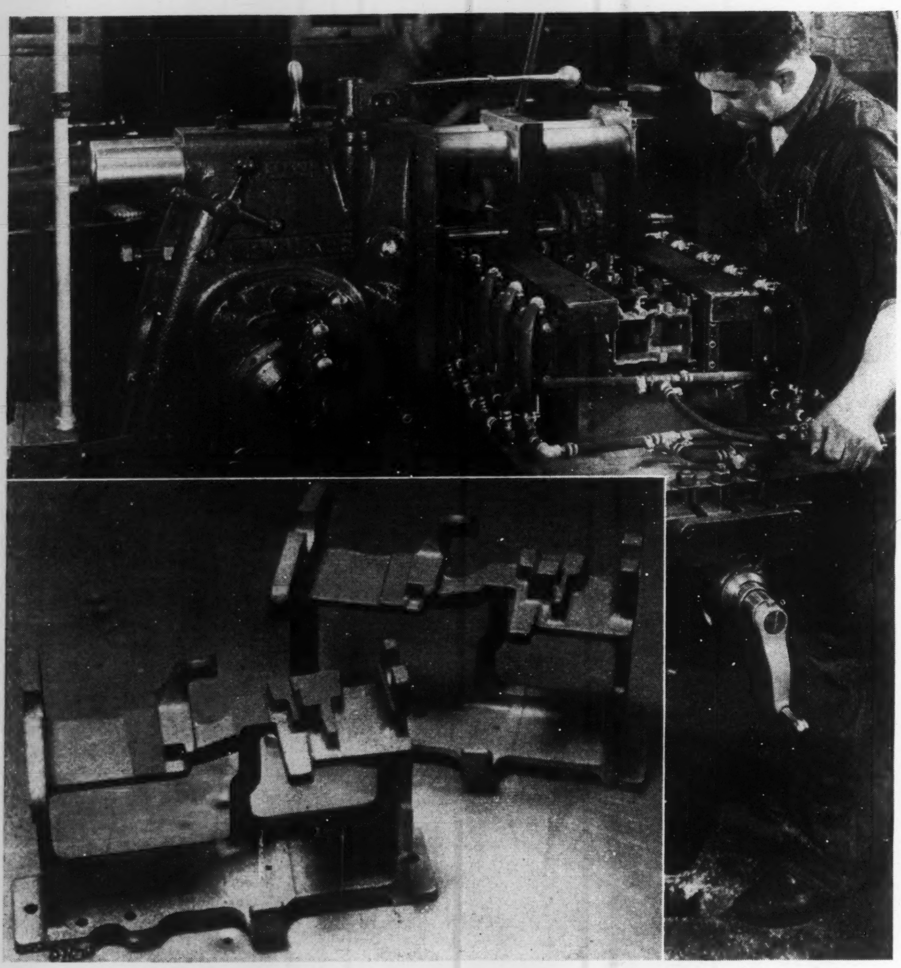


Fig. 20—Left—Gang milling a light cast-iron frame with carbide cutters. The 4-inch surface area is finished at 16 inches per minute, producing 128 pieces per hour

and surface finish, surfaces to be milled should be narrow and where possible designed contemplating the use of medium-diameter cutters. This eliminates the necessity for super spindle speeds which are usually required with small-diameter cutters. Use of extremely large-diameter face mills and long slab mills should be avoided. Again, flimsy or frail sections should be avoided inasmuch as they usually necessitate slow speeds and extremely light cuts to insure against breakage, distortion and warpage.

As noted in Part XXI, horizontal-spindle machines are preferable for heavy, high-speed work. Thus, it is well to avoid end-mill work. Where end-milled surfaces are necessary, however, cutters 1-inch in diameter or greater should be used if at all possible. Small-diameter end mills are frail and require slow speeds as well as relatively large tolerances on the parts milled. Radii produced by end milling—both those created by the side of the mill as well as those produced by the edge or corner radius—should be kept constant, *Fig.* 21, to obviate the need for two operations. As a rule, corner or edge radii to be produced by end mills should be limited to a maximum of 50 per cent of the cutter radius. Preferably, radii should be small to improve cutting action on the face or end of the cutter—0.50-inch being an ideal minimum radius.

In specifying slot widths under one inch it is usually preferable to use nominal fractions and assign a smaller dimension to the mating tongue. This avoids the necessity of special-width slotting cutters and the tongue part can be milled as desired with an adjustable straddle cut. Standard slotting cutter widths run in 1/16-inch increments up to ½-inch, ⅛-inch increments up to 1 inch and those over 1 inch are special but should be specified in ⅛-inch increments.

Where wide slots are contemplated — over one inch — design should provide for the use of half-side mills for maximum economy. Since these mills cut only on the side and periphery, relief or clearance at the middle of the slot is necessary, *Fig.* 22. Unless relief can be readily provided by casting, forging, etc., special-width or interlocking cutters must be provided, often at extra cost and slower production.

Slot depths greater than three times the cutter width should be avoided whenever possible. Deep slots milled from the solid make for low production since slow feed rates are necessary to avoid cutter "wander". In calculating maximum

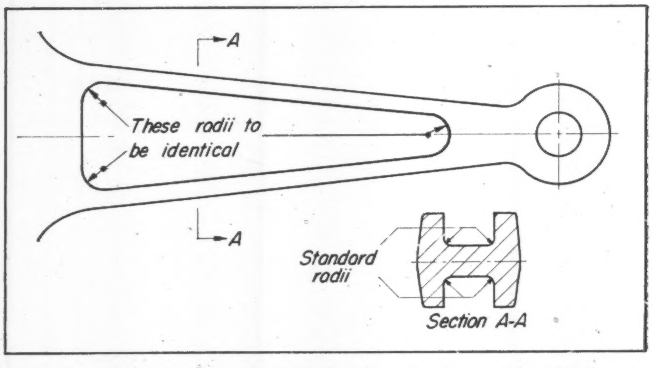
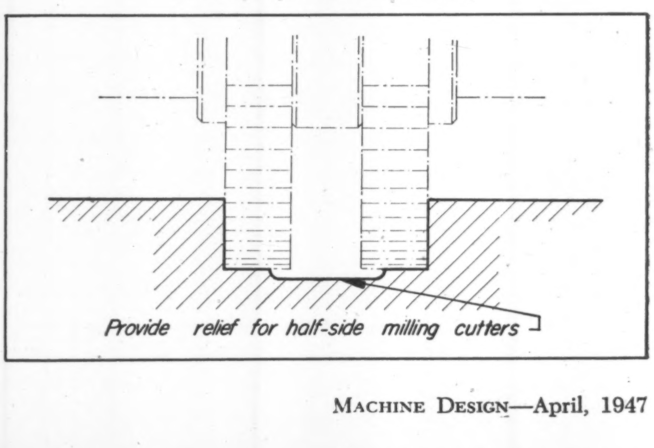


Fig. 21—Above—Proper standard radii for end-milled surfaces should always be used to assure the minimum in tooling and setup costs

Fig. 22—Below—Wide slots should be specified as shown to simplify accurate milling

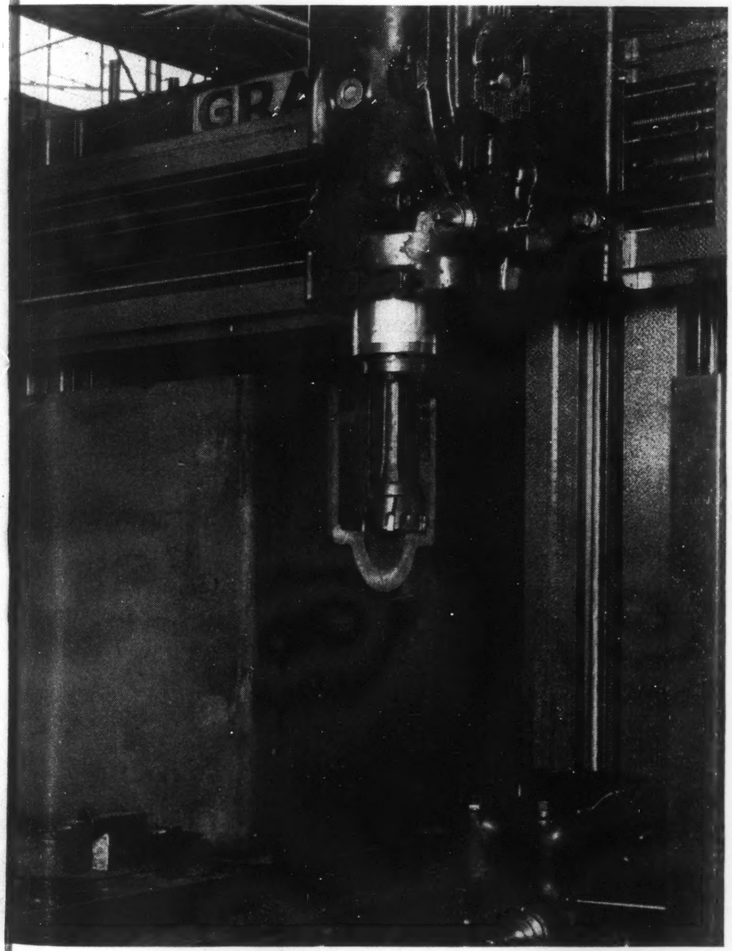


depth of slot for a specific peripheral cutter, allow ¼-inch clearance between the arbor collar and the work surface. End-milled slots can be much deeper of course, and are sometimes justified, even at some sacrifice in the cost of the milling operation, *Fig.* 23.

Where lugs or ears are specified, advantage should be taken of the rapid combination surface and slot milling possible by means of cutter "gangs". Bottom of slots as well as outer surfaces of such lug or ear projections should have the option of plunge or through milling, whichever is most economical, by allowing for either a radius or straight bottom edge, *Fig.* 24. Also, allowance should be made for standard corner radii which, naturally, should be specified to obviate special grinding or cutters. As a rule the corner radius for a 1/32-inch wide cutter is 0.005 to 0.015-inch; for a 1/16-inch wide cutter, 0.010 to 0.030-inch; for 3/32 to 3/16-inch wide cutters, approximately 0.030-inch; etc.

Regarding keyways, it is preferable to design for use of a slotting cutter rather than an end mill. Thus, unless a special key is necessary, keyway ends should be shown with a standard cutter radius runout. As a rule, multiple keyways in a common line are preferred to one long plain keyway. Multiple plain keyways spaced radially around a shaft are not considered good practice for milling; angular tolerances are sometimes difficult to maintain. Splined sections should be specified in such cases and designed for production by hobbing.

Fig. 23—Below—Surface finish must be sacrificed where long spindle extensions are required, and such designs are well to avoid if possible



Wichita City Library

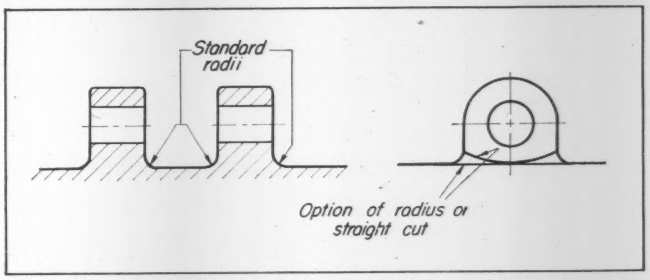
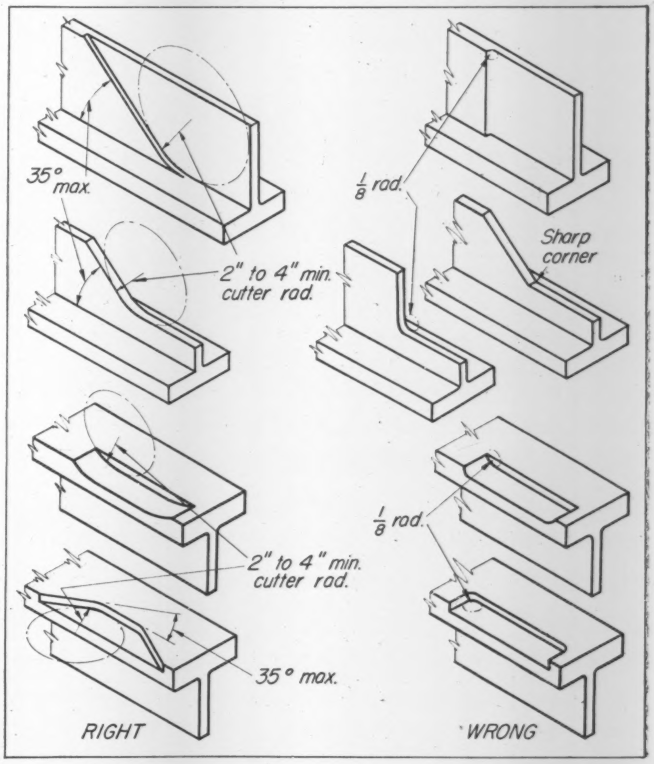


Fig. 24—Above—To simplify production problems lug design should have option of flat or radius-milled corners

Fig. 25—Below—Some of the right and wrong methods of designing long, complicated parts to be produced on a continuous cam track tracer miller



Angles between milled faces should be 90 degrees wherever possible. To guarantee easy cleanup as well as to avoid special form cutters, the angle should be greater than 90 degrees especially where the shoulder need not be machined. Undercut shoulder portions should, of course, conform to standard 30-degree, 45-degree and 60-degree cutters available. Internal corners of such cuts should be shown with a 1/32-inch to 1/16-inch fillet rather than a sharp corner, both simplifying grinding and prolonging cutter life.

Where external edges are to be rounded, standard concave cutter radii should be specified. The cutter radius used, however, should be slightly greater than the tangent radius to avoid undesirable nicking of the sides of the part otherwise encountered. If a full 180-degree radius is desired, these also should conform to standard cutter dimensions. As a rule when plain external or corner radii are greater than obtainable with standard cutters, especially if production is to be high, economies of production speed as well as cutter and sharpening costs dictate the use of bevels in lieu of radii. This makes possible the use of ordinary face mills and often carbide face mills. Naturally, if the radius is along a compound surface a special mill can seldom be avoided.

As mentioned previously, avoidance of cuts requiring small-diameter cutters is advantageous, especially with high-speed milling where the cutter body acts somewhat as an added flywheel. Thus 6 and 8-inch diameter cutters are widely used and preferred. Obviously, the radii generated by such cutters are 3 and 4 inches, but in general it can be said that by specifying large radii of, say, 2 inches or greater, production can be greatly facilitated.

Careful consideration of the machine and cutters to be used is especially valuable on intricate or complicated work such as long spars, etc., which normally necessitate an automatic tracer miller or like machine. The details shown in *Fig.* 25 indicate good practice in designing such parts. Since it is undesirable to stop the cutters until the entire part has been finished, design details should be such as to allow the cutter to plunge into and out of the work as required in following the pattern. As noted, it is impossible to obtain the exact cutter radius if more than 35 degrees of cutter circumference is required. In fact, it is best to avoid producing the exact cutter radius.

With most small parts trouble is often encountered in providing accurate location in fixtures. Serious consideration should be given this problem, and where parts to be milled are large, say automotive engine blocks, large machine beds, etc., and all surfaces available are curved or slanted, it is advisable to consider the addition of cast or welded-on pads or projections to provide the locating surfaces. Similarly in certain cases such pads are valuable for holding or clamping.

Specific limitations of design inherent in each of the methods and types of milling outlined in Part XXI are apparent to a certain extent from the discussion. Of primary interest in this respect is the versatility of the automatic-tracer type millers briefly mentioned. An almost unlimited range of complex surfaces can be produced with these machines in quantity and at reasonable cost, *Fig.* 26. Parts for guns and other machines necessarily designed for functional perfection can be readily produced by means of one of the methods of complex surface milling: (1) Form-relieved or shape-profiled cutters, the contours of which are reproduced in reverse on the workpiece; (2) standard cutters, the paths of which are varied relative to the workpiece to reproduce the desired contours, and; (3) a combination of these two methods in which the profiled cutter is made to follow an irregular path. Along with the automatic tracing or cam-following machines, rotating or oscillating fixtures, mechanically synchronized rotation of fixture with table or spindle, gangs of plain, formed or plain and formed cutters, etc., all add to the design possibilities.

Fig. 26—Automatic tracer millers make possible the mass reproduction of an almost unlimited range of complex surface parts for machines

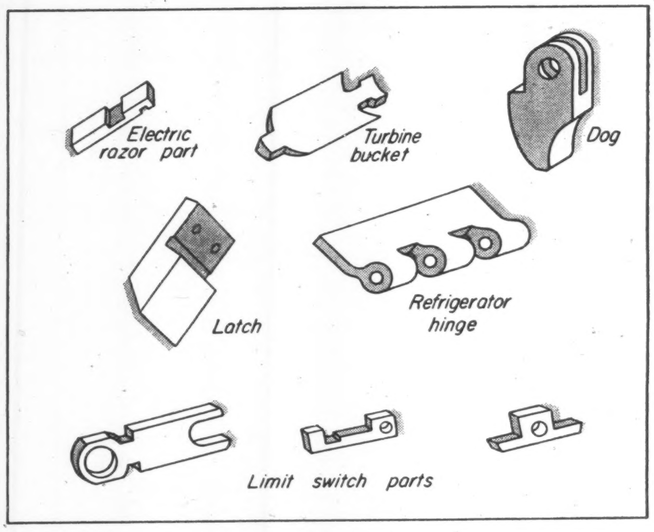
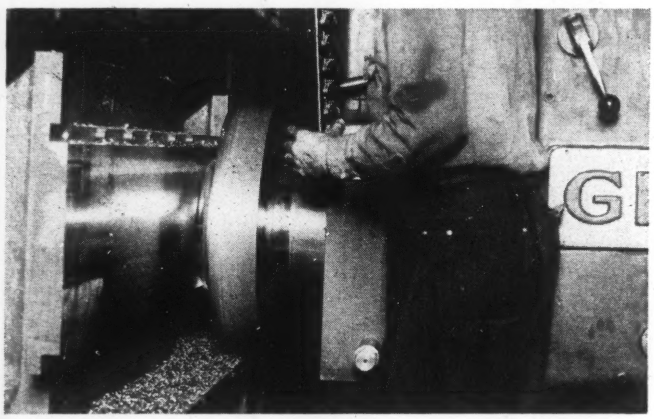


Fig. 27—Above—Parts produced on the automatic bar-stock miller indicate the range of design possibilities. Tolerances range around plus and minus 0.001-inch

Fig. 28—Below—Milling the surface of 0.40-carbon steel rack forging with negative rake 12-inch diameter flywheel type carbide cutter at 24 ipm feed and 475 sfpm speed. The 50-hp head removes 50 cu. in. of metal per minute



Use of form milling, however, should be carefully considered in the light of the production difficulties with such cutters. It is often difficult to obtain desirable tooth-angle relationship in form-relieved cutters; they require painstaking care in design, are difficult to check dimensionally and, most difficult of all, require infinite care in maintaining cutter form and dimensions through a series of resharpenings. Probably the greatest limitation of the form or profile cutter is its single purpose. Such cutters can be obsoleted by a single necessary design change and consequently should be avoided wherever possible for maximum economy in overall production.

Thread milling is exceptionally well adapted to production threading of blind holes as well as for any threading job where high accuracy, alignment and finish are necessary. Although most multiple thread milling cutters are necessarily special, they make possible the removal of the imperfect start portion of both male and female threads of any type, a feature of design not economically available by other means.

Touching upon the design possibilities and limitations of the automatic bar stock miller, the parts shown in *Fig.* 27 are a few that have been produced on these machines and present a fair idea of the range and versatility. As a rule, gangs or stacks of cutters rather than form cutters are preferred for this machine; staggering the individual cutters obviates chatter by maintaining two or more teeth in the cut at a time.

MATERIALS: Normal rates of metal removal at accepted speeds and feeds common to high-speed steel cutters have long determined to a considerable extent the suitability of a material for milling. Naturally, this eliminated a good many of the low-machinability or totally nonmachinable metals from serious consideration unless their physical characteristics were imperative. The advent of high-speed carbide milling, however, has brought into the practical production range most of these materials, some of which can now be machined at higher rates than ordinary steels.

The low-carbon steels ranging up to 10 points of carbon are highly desirable for many electrical applications and are considered most suitable for weldments, but necessary milling feed rates around one inch per minute coupled with extremely poor surface finish made their use impractical in many cases. With proper carbide technique these materials can now be milled successfully at high feed rates and speeds ranging around 1000 surface feet per minute while that for ordinary steels ranges in the neighborhood of 500 surface feet per minute, *Fig.* 28. In addition, surface finish, while not as good as with harder materials, is highly satisfactory. Included in this low-carbon category is also wrought iron, once considered an incorrigible as far as machining is concerned.

Carbide milling techniques likewise affect the alloy steels. All alloy steels such as the chrome-manganese and chrome-moly series can be milled in the heat-treated state, ferrous materials brinelling as high as 600 being successfully milled. In one pass it is now possible to mill the SAE 4340 series, in heat-treated state, to superior finish and size specifications with little or no heat effects since in high-speed carbide milling, often performed dry, chip removal is so fast that the heat of cutting is retained primarily in the chips, *Fig.* 29.

This speed of metal removal makes possible the economical milling of another group of metals—those with work-hardening characteristics. Thus the armor plates, stainless steels and similar materials can now be milled at feed rates up to 25 inches per minute and cutter speeds as high as 900 surface feet per minute. Even corrosion resistant materials such as Ni Resist and type 304 stainless can be readily handled with carbide cutters.

A general idea of where some of the various engineering materials fit into the milling picture may be gained from the Chart in TABLE I, Part XXI, which also gives the relative machining characteristics with high-speed cutters or carbides. From this table the ideal characteristics of the lightweight nonferrous alloys are quite apparent, hence these metals deserve serious consideration in design of all types of machine parts. At surface speeds of 12,000 to 15,000 feet per minute at the cutting tips, sur-

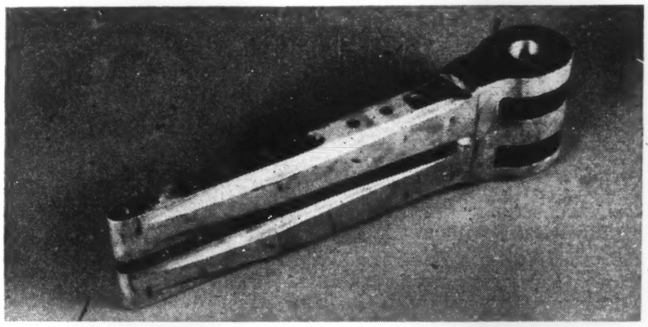


Fig. 29 — Above — Aircraft wing-hinge forging of SAE 4340 heat treated to 402 brinell, with a slot 10-inches deep by 0.505-inch wide, milled at 13 inches per minute with a carbide cutter to plus or minus 0.005-inch on width and 0.002-inch on parallelism. Finish ranges from 8 to 10 microinches

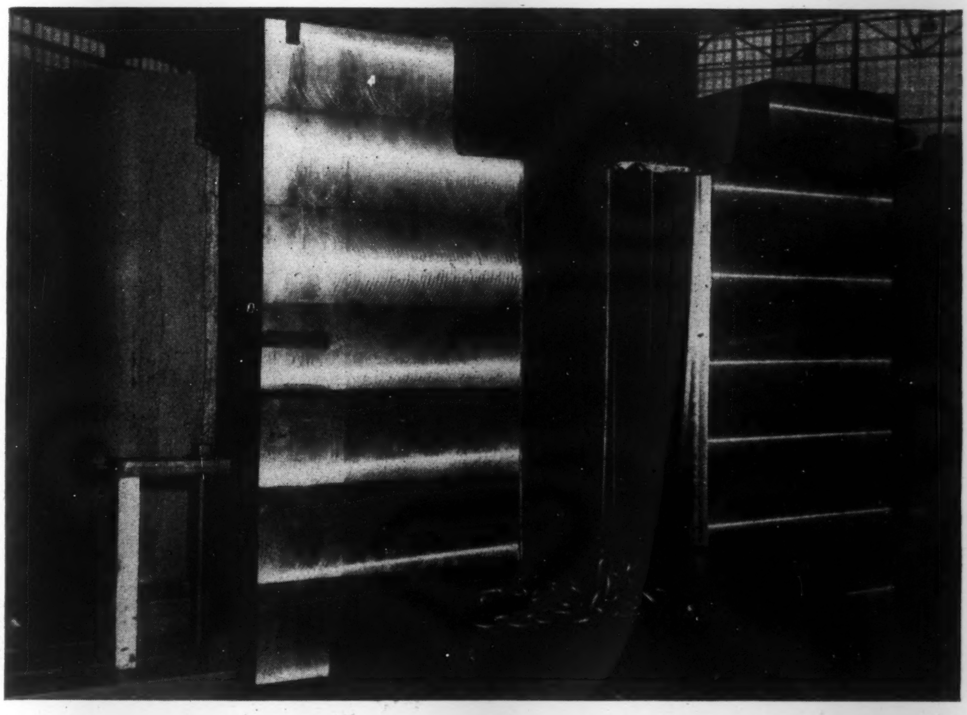


Fig. 30 — Right — Low-carbon weldment showing a large surface carbide milled area. Joining marks cannot be detected by profilometer

face finish can be obtained ranging from 10 to 15 microinches even at feed rates as high as 300 inches per minute. In addition, under these conditions tool life is extremely long.

Tolerances: Wherever carbide tooling and high speeds can be utilized in milling, the tolerances which can be readily maintained in production as well as variations from piece to piece reach a minimum figure. With ordinary milling methods using high-speed steel cutters, tolerances ranging around plus or minus 0.005-inch with surface finish from 50 to 250 microinches is normal and to obtain the finest finish or tolerance on dimensions both roughing and finishing cuts are usually necessary. With carbide-tipped cutters, however, average surface finish obtainable in production ranges between 20 to 40 microinches and dimensional tolerances to as low as plus or minus 0.0005-inch readily held in many instances.

BECAUSE of numerous requests for reprints of this series of articles, the first fifteen parts are now available as a bound volume. Complete information and particulars can be found on page 306 of this issue

Generally, as hardness increases, the finish produced with carbide cutters improves and surfaces under 10 microinches have been regularly produced, *Fig.* 29. The value of fine surface finish as well as virtual nonexistence of tool marks on such highly stressed parts is self evident and deserves serious consideration.

Likewise, the surface flatness obtained at these high production speeds is of much value. Leakproof joints are possible without the use of gaskets—flatness being of an order such that nongasketed hydraulic joints operate satisfactorily under 1200-psi pressures. Grinding operations ordinarily required on such surfaces are thus eliminated, reducing cost considerably. An idea of surface finishing possible can be gained from *Fig.* 30, the low-carbon weldment shown having been finished by a series of 4-inch passes to such an accuracy that the matching lines cannot be detected by a profilometer. Naturally, such results can only be had on machines in first-rate condition and with proper operation.

In producing long, accurate semicircular grooves, the shape-profiled inserted-blade cutter shown at left in *Fig.* 31, which is in effect a slab milling type, presents difficulty because cutter runout, revolution marks, etc., are hard to eliminate. Where accuracy and finish must be of a high order, say in the neighborhood of 100 microinches, the other type cutter shown will produce a groove straight within plus or minus 0.002-inch in a 10-foot length while diameter can be held within 0.001-inch.

Radial cams of various sizes can be produced on rotary-head or rotary-table machines with cam groove radii held to plus or minus 0.001-inch. Special tracer millers have regularly produced aircraft propeller cylindrical cams to within an accumulated error of less than 0.0005-inch.

Diametral accuracy of forms and threads produced on the thread millers is unusually good, breech ring lock threads of 3 to 4-inch diameter being readily produced to plus or minus 0.001-inch on dimensional limits and parallelism. Coarse and fine thread forms up to 10 and 12-inch diameters in both straight and tapered types have been milled in production to within plus or minus 0.003-inch on the pitch diameter. Closer tolerances can often be held but naturally necessitate more frequent cutter grinding and much higher costs. Where design demands, male and female threads can be produced in quantity with matching points varying less than 0.031-inch peripherally after assembly.

An important factor often overlooked in designing is that aluminum forgings shrink lengthwise after the skin is cut away; if the shrinkage is nonuniform and the tolerances too close, the part may have to be rejected. Thus with aluminum forgings and also extrusions for that matter, limits should be as liberal as possible, especially between rough and machined surfaces, the best results being obtained by machining all over.

Collaboration of the following companies in the preparation of this article as well as the assistance lent by Dr. H. A. Frommelt, consulting engineer on carbide milling, Milwaukee, is acknowledged with much appreciation:

Cincinnati Milling Machine Co. (*Fig.* 26)	Cincinnati
Cooper-Bessemer Corp.	Mt Vernon, Ohio
Farnham Manufacturing Co. (*Fig.* 25)	Buffalo
Farrel-Birmingham Co. Inc.	Ansonia, Conn.
G. A. Gray Co. (*Figs.* 23, 28 and 31)	Cincinnati
Kearney & Trecker Corp.	Milwaukee
Kennametal Inc. (*Figs.* 29 and 30)	Latrobe, Pa.
Kent-Owens Machine Co. (*Fig.* 27)	Toledo, Ohio
Midwest Tool & Mfg. Co. (*Fig.* 20)	Detroit
Westinghouse Electric Corp.	Pittsburgh

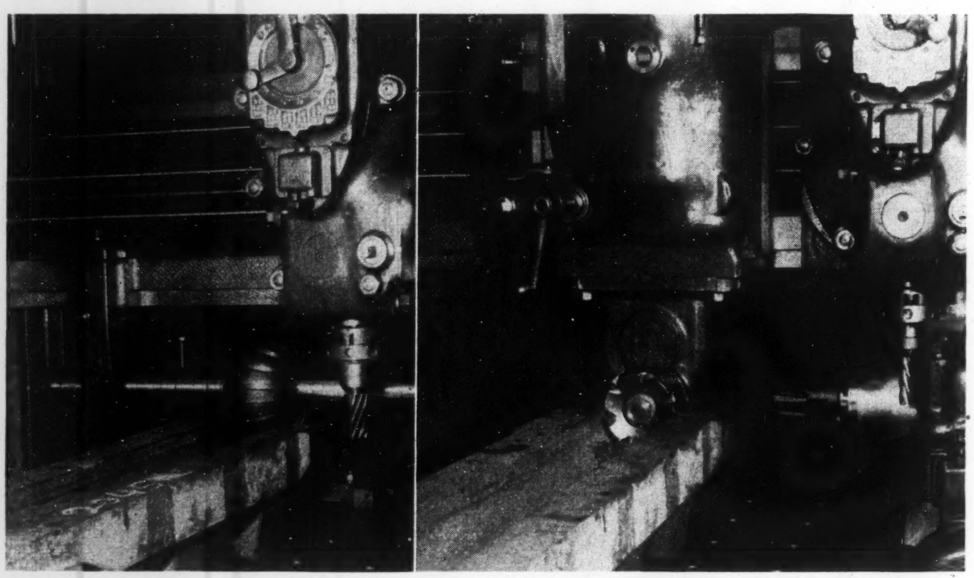
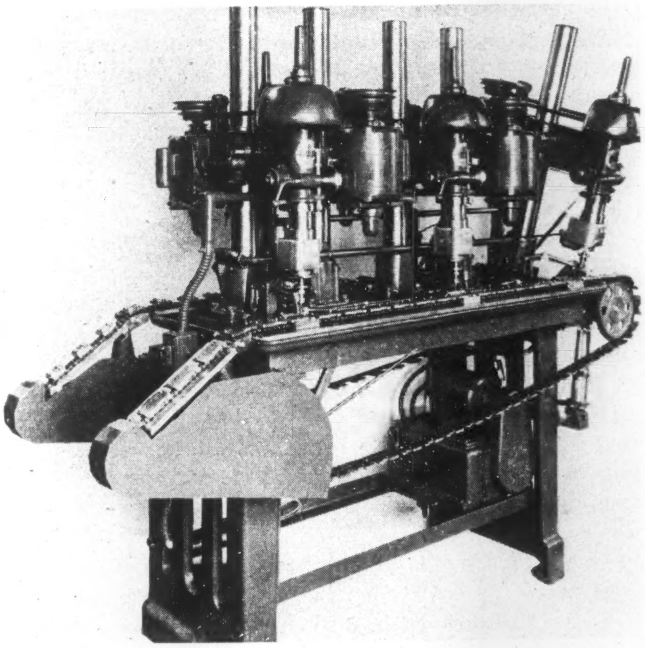


Fig. 31—Cutter in right view will mill a long, semicircular groove to greater accuracy than the profile slab mill shown at the left

Applications

of engineering parts, materials and processes



Packaged Elements Form Production Machine

PACKAGED elements make possible the high-speed, automatic production of small plates in the automatic tapping machine, left. Five Walker-Turner fifteen-inch drill presses are mounted with proper spacing and angular relationship so as to tap pieces brought into position by roller chain-conveyor. Two finished parts drop off end of conveyor each cycle.

Shells Simultaneously Trimmed and Beaded

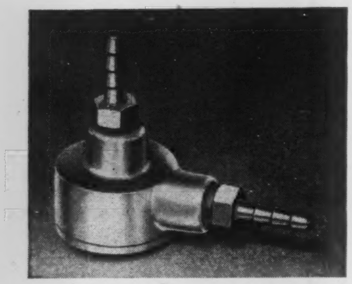
STAMPINGS are trimmed and beads formed simultaneously on the Whiting Stamping Trimmer seen above. Flash-encumbered stamping is placed on a supporting roll and the forming roll pneumatically forced against it. Pressed between the rotating dies, the part is trimmed and beaded in one revolution. Only a few seconds are required for the operation.

Plastic Rollers Have Less Breakage

USED for the roller of the Clemson lawnmover, left, Tenite greatly increases life of the machine. Water and shock proof, the plastic is undamaged by moisture absorption or by hard blows from pebbles and sticks hidden in grass. Roller consists of three molded sections to facilitate turning the mower without damage to the sod.

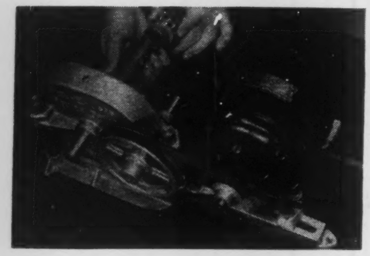
new parts and materials

Air Exhaust Valve



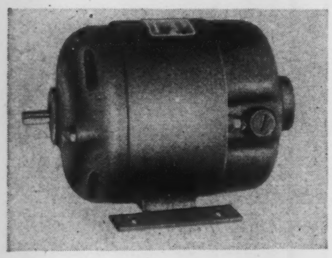
NEW KIND of quick exhaust valve for use with pneumatic cylinders has recently been announced by the Mead Specialties Co., 4114 North Knox Ave., Chicago 41. The unit acts on the principle of a bellows to expel the air more quickly and automatically opens as soon as the air supply is shut off. It can be attached directly to air cylinders with a ¼-inch pipe nipple or cut into the air hose adjacent to the cylinder. Overall dimensions exclusive of nipples are: 1¾-inch diameter, 1½-inch high, 2¼-inch long. Nipple openings are tapped ¼-inch NPS.

Variable-Speed Drive



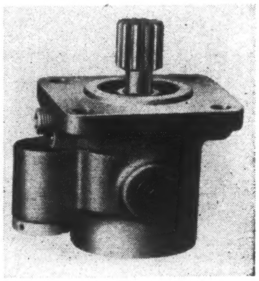
FRACTIONAL - HORSEPOWER variable - speed drive with range of 20 to 750 rpm when used with 1725-rpm motors is now being made by the Flinchbaugh Co., 750 South Court St., York, Pa. The unit has base and housing of aluminum and height adjustable by length of posts used. Universal mounting is used for motors under ½ hp. Either direction of shaft rotation can be obtained by mounting motor right or left on base and power drive does not depend on the direction of motor rotation.

Small Universal Motor



AVAILABLE in ¼ and 1/3-hp sizes, new general-purpose universal motors, recently developed by the Cyclohm Motor Corp., 5-17 46 Rd., Long Island City, N. Y., operate at 5000 and 6000 rpm, respectively, at 115 volts. Motors are ball-bearing mounted, and are fan cooled and rated at 40 C rise. They are reversible and can be supplied with reversing switch if so desired. Thermal overload protection can be furnished with alternating-current operation. Motors are 5 inches in diameter, 7 inches long and weigh 11¼ lb.

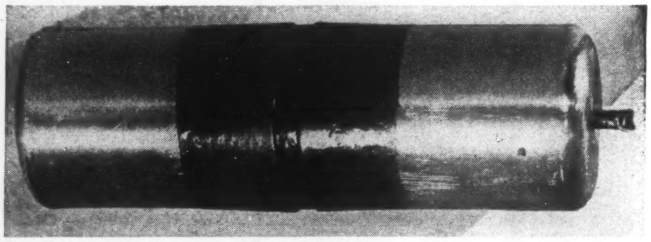
Rotary Vane Pump



LIGHTWEIGHT, small-size nonpulsating type pump is now being made by the Romec Pump Co., 101 Abbe Rd., Elyria, Ohio. The unit, known as Model RD-7750, is a self-priming positive-displacement pump weighing only 14 ounces. It is so designed that by varying materials and accessories it can be used to move fluids varying in viscosity from a watery consistency to SAE 60 oil. Pump is available with by-pass relief valves for fuel and oil delivery and various drive couplings and mounting flanges for use with either engines or electric motors. Unit has a capacity of 75 gallons per hour, a speed range up to 4000 rpm, and operates at pressures up to 60 psi.

Mercury Switch

SMALL, metal mercury switch Type D-100, having a fused hermetic seal between metal and ceramic, is being manufactured by Mercontrol, Inc., 278 Pearl St., New York 7. Switch is 4 inches long, 1¼ inches in diameter and has a continuous current rating of 100 amperes at 110 or 220 volts dc or ac. At full load rating of 100 amperes, temperature rise of the switch is only 25 C above its surroundings under normal operating conditions. Switch has been flash tested with currents as high as 500 amperes.



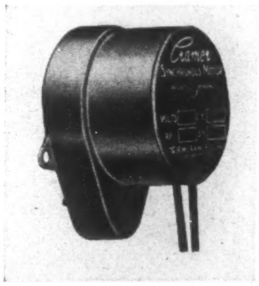
Welding Electrode

FLUX-COATED METAL arc electrodes now being produced by Eutectic Welding Alloys Corp., 40 Worth St., New York 13, permit ac-dc metal arc welding on stainless steel at low base-metal temperatures. Electrodes in alloys 18-8, 25-12, 25-20 and 310 are available in 3/64 to 3/16-in. diameters.

Bar Steel

SPEED TREAT STEEL, a product of W. J. Holliday & Co., Hammond, Ind., is now available for the first time in standard-sized rolled flats. Available are sizes ½ to 3 inches thick, in standard widths, and 20-ft lengths. Among products for which Speed Treat may be used are: Gears, sprocket wheels, trimmer dies, bearing and wearing plates, shallow molds and machine ways.

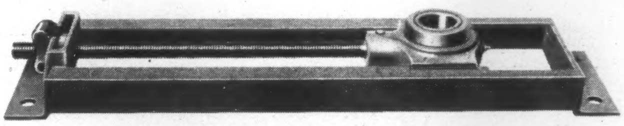
Synchronous Motor



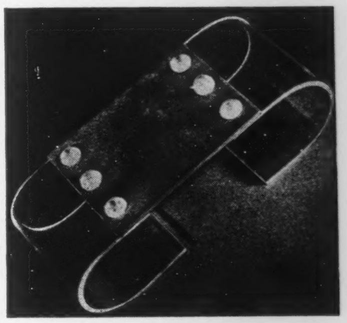
DEVELOPED to fill need for a small, powerful, precision-built, self-starting synchronous motor of high operating efficiency, the new Cramer SX synchronous motor made by the R. W. Cramer Co., Centerbrook, Conn., embodies features designed to give it a wide range of applications in the instrument and control fields. SX motor is compact, 1½ by 2⅛ by 2⅜ inches in size, has torque of 30 ounce-inches at 1 rpm, consumes only 2.7 watts at 115 volts, 60 cycles. It has a rotor speed of 240 rpm at 60 cycles and is available with one of 28 standard gear trains ranging in speeds from 60 rpm to one revolution in 24 hours. Motor is intended for applications requiring constant speed at a given frequency, is said to be particularly suited for timing devices, recording instruments, communications equipment, heating controls, and signaling systems.

Ball-Bearing Take Up

STEEL-FRAME ball-bearing take-up for conveyor application has been placed on the market by the Dodge Mfg. Corp., Mishawaka, Ind. Take-up incorporates Dodge SC take-up units consisting of a ball bearing unit enclosed in a cast-iron housing provided with ways. Housing has a hole for receiving the unthreaded end of an adjusting screw. Take-up has a welded-steel frame designed to afford ample strength without excess weight, is equally strong in tension and compression. Adjustment is accomplished by turning brass capatan-head nut.

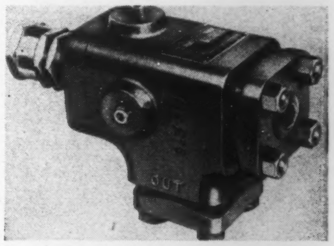


Plastic Rivet



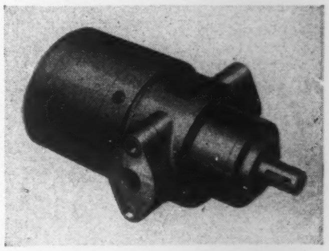
PLEXIGLAS rivets for use in fastening metals, rubber and other plastics have recently been developed by the Douglas Aircraft Co., Santa Monica, Calif. The rivets offer designers several advantages heretofore not attainable. When used on fragile materials the acrylic fasteners may be clinched by heating and expanding with air pressure. Since the rivets will not rust or corrode they are ideal for use in radio or high-frequency apparatus or in food containers, etc.

Pressure Relief Valve



PERMITTING instantaneous action and thus preventing objectionable pressure peaks, a new 5000 psi relief valve now being manufactured by Superdraulic Corp., Dearborn, Mich., provides high efficiency and long life. The new valve is said to eliminate disadvantages of previous designs and to incorporate such features as elimination of squealing and chattering, and accurate maintenance of setting.

Hydraulic Power Unit

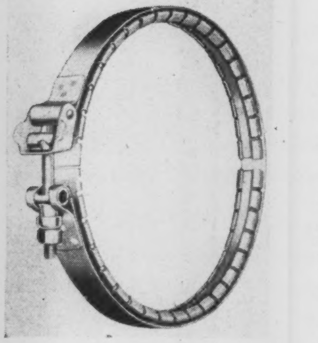


RECENTLY DEVELOPED line of piston-type Hydroilic pumps known as the 3500 series has been announced by the Denison Engineering Co., 1160 Dublin Rd., Columbus, O. The series presently consists of three units covering the delivery range 6 to 32 gpm at 3500 psi and 1200 rpm. The smallest pump, Model PA-062-500, is light and compact, has a delivery of 6 gpm at 1200 rpm, and 9.75 gpm at 1800 rpm. It is recommended for use as an auxiliary pump in circuits demanding a high-volume, fast-traverse delivery up to the actual working peak of a high-pressure low-volume application. Model PA-172-400, closely resembling the smaller model, delivers 17 gpm at rated speed, while Model PA-322-400 delivers 32 gpm at rated 1200 rpm. All three pumps are available with flange, foot or face mountings, while special mounts may be adapted. Number of design features of new series include: Elimination of thrust bearings, axial-piston design, pressure-balanced piston shoe eliminating direct contact between shoe and cam plate. Because of these innovations the pumps are said to be unusually quiet and efficient (95 per cent) in operation.

Vertical Induction Motor

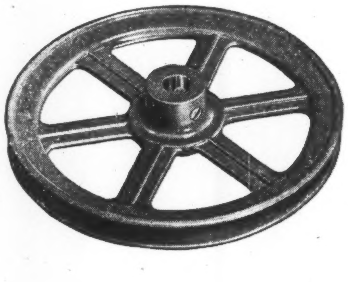
HOLLOW-SHAFT, vertical induction motors designed for pump drives have been added to the General Electric Tri-Clad line. The new units are available in ratings from 1 to 500 hp with all speeds and frequencies, and are suitable for use on deep-well pumps and process liquid pumps. For motors rated 10 hp at 1800 rpm and larger, the new line features a system of controlled lubrication. Bearings, punchings and windings are cooled by a double-end ventilating system and a protective "self-release" coupling prevents damage to pump or motor by motor reversal. Rotor windings in all ratings provide suitable starting torque with low starting current.

Manifold Coupling



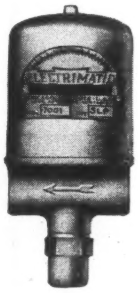
HIGH-TEMPERATURE manifold coupling, affording seal for all types of manifold joints operating under high temperatures and excessive vibration, are now being offered by Marman Products Co., Inc., 940 W. Redondo Blvd., Inglewood, Calif. Wedging action of the retainer ring draws together flanges of the manifold joint as the coupling is tightened. High axial component of the clamp band tension is transmitted into wedging action, providing a positive seal. Feature of the coupling is the vented construction of its retainer ring making it possible for the coupling to remain at one-half the temperature of the manifold. Coupling is designed for joining any manifold equipped with flanges.

V-Belt Pulleys



LINE of V-belt pulleys 1½ inches to 16 inches in diameter has been completed by the recent addition of 11 and 16-inch diameter pulleys by the Congress Tool and Die Co., Die Casting Division, 3750 E. Outer Drive, Detroit 12. These form an addition to a full line of cone pulleys, variable-speed pulleys and couplings.

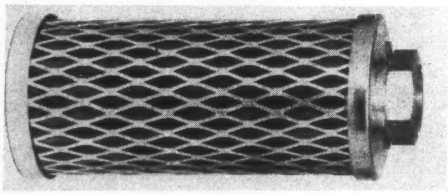
Solenoid Valve



TYPE SL solenoid stop valves manufactured by the Electrimatic Division of the Simoniz Co., 2100 Indiana Ave., Chicago, are of packless construction, direct acting and tight seating. They are designed to start and stop the flow of liquid refrigerants, water, brine and gas and are said to be quiet in operation. Operating from 60 cycle current at 115 to 230 volts and furnished with condensers for dc operation, the units have manually-operating stems for use in the event of a possible current interruption. The heavy forged brass body is said to be a safeguard against distortion.

Sump-Type Oil Filter

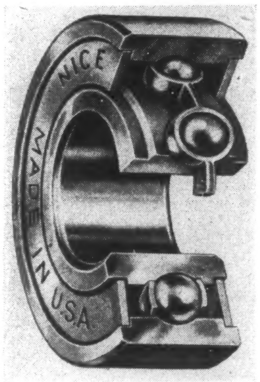
SUMP-TYPE filter adaptable for all types of oil recirculating machines has been placed on the market by Marvel Engineering Co., 549 W. Washington St., Chicago 6. Filter consists of a special reinforced-wire cloth, formed into corrugations for greatly increased filter area. This unusual design provides three times the surface now available in comparable units. The Synclinal filter is available in most standard units sizes and is easily installed or cleaned.



Welding Fittings

STAINLESS-STEEL welding fittings in a complete line have been announced by Tube Turns, Inc., 220 E. Broadway, Louisville, Ky. The line includes 180-degree long radius returns, 90-degree elbows, 45-degree elbows, reducers, crosses, etc. Fittings may be had in three grades of stainless steel: Type 304 is 18 chromium, 8 nickel; type 347 is 18 chromium, 8 nickel; type 316 is 18 chromium, 8 nickel, 2 molybdenum.

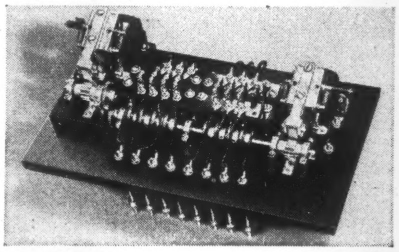
Low-Cost Ball Bearings



NOW being marketed by the Nice Ball Bearing Co., 2925 Hunting Park Ave., Philadelphia, Pa., is a new line of low-cost, unground, radial ball bearings. The bearings are designed for adaptation to the many applications requiring inexpensive, high-quality angular bearings and are recommended for medium loads, and for maximum speeds in the neighborhood of 2500 to 3000 rpm. The new Series 3000 bearings incorporate one-piece inner and outer races turned from high quality steel and heat treated. They are available double shielded, with one shield, or without shields and can be furnished grease packed or without grease, as desired.

Multipole Sequence Relay

USEFUL FOR REVERSING separate circuits simultaneously, ratchet-operated multipole sequence relay has been added to the line of relays manufactured by Struthers-Dunn, Inc., 146-150 N. 13th St., Philadelphia 7. The new unit, known as Type 96AFA, is adaptable to numerous applications involving the addition and subtraction of loads such as switching in or out of individual units from a bank of capacitors. The relay is a two-coil type, with one coil stepping the cam shaft forward a step at a time. Second coil steps the shaft in the reverse direction. Mechanical stops limit the forward and reverse travel of the shaft. Standard ratchets supplied have 12 teeth, thus a total of 12 contacts may be obtained in a sequence with no more than 6 contacts between each pair of bearing supports. Operating coils are for ac use only.

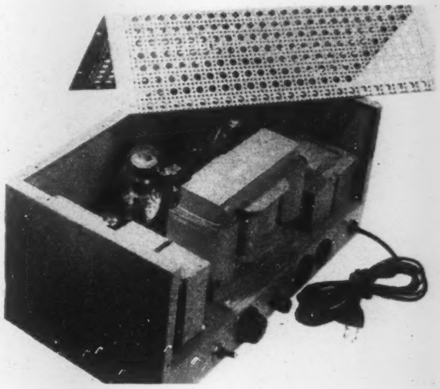


Circuit Breaker

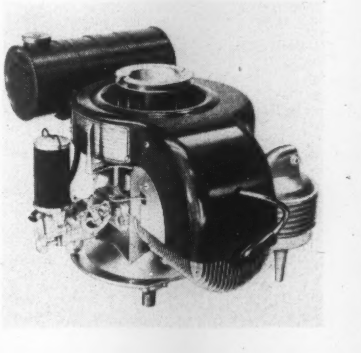
NOW BEING MARKETED by the Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, is a new line of circuit breakers known as Quicklag. The new type breakers are available in single or double pole units rated at 10 to 50 amperes, 125 to 250 volts ac. They provide a tripping action which combines the inverse-time limit characteristics of bimetal thermal action on overloads, with the operating speed of magnetic-trip action on short circuits. Circuit breaker incorporates a redesigned De-ion arc chute eliminating the need for a vent screen on the bottom and thereby permitting mounting flush to pan. Other improvements include: Sturdier operating handle, internal design requiring less handle motion, hole in handle permitting more satisfactory method of attaching handle extension, and smooth flush surface eliminating dust trapping.

Voltage Regulator

NEWEST addition to line of alternating current line voltage regulators manufactured by Sorensen & Company, Inc., 375 Fairfield Ave., Stamford, Conn., is the new Model 500. Designed for low-cost applications the regulator will maintain output voltage within plus or minus 0.5 per cent of the adjusted value during variations of input voltage from 95 to 125 volts, and variations in loads from 50 va to 500 va. Regulation is accomplished by electronic means, no moving parts are used. A result is a transient recovery time of approximately four cycles. The unit functions independently of frequency variations of as much as 10 per cent and has harmonic distortion of less than 5 per cent.



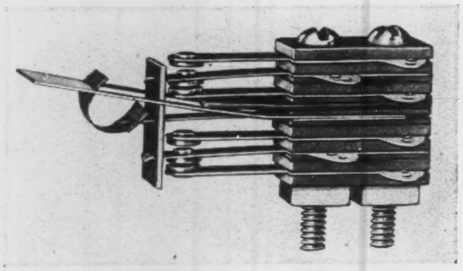
Single-Cylinder Two-Cycle Engine



ONE OF a new series of industrial engines now being built by McCulloch Motors Corp., 6101 W. Century Blvd., Los Angeles 45, is the Model 1200D. It is a single-cylinder, two-cycle, air-cooled type weighing only 24 lb and developing a rated 2.5 hp at 2500 rpm. The unit possesses all the advantages of the two-cycle type—lightweight, small size, simplicity, fast acceleration and low maintenance. The McCulloch engine is also said to provide easy starting and smooth idling. Engine is characterized by the patented "reverse-flow" scavenging system. This new design permits the use of flat-top, nondeflecting pistons since directional control of the incoming fuel charge is achieved through the use of guide vanes in the intake ports rather than through piston-top deflectors. Detonation resulting from hot spots on piston tops is thus greatly reduced. The unit is a vertical-crankshaft engine designed especially for such applications as pumps, lawn mowers and farm equipment, etc. It is air-cooled and has a high-tension flywheel magneto with a rope starter. Bore and stroke are 2 inches, displacement is 6.28 cubic inches. Overall dimensions including gas tank and spark plug are: Height 14.6 inches, length 17.8 inches, width 14.2.

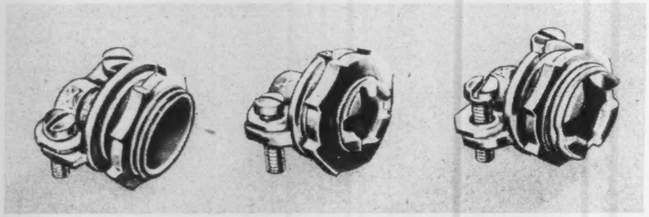
Snap Switch

OPEN-BLADE SWITCH of the snap-action type has recently been announced by the Acro Electric Co., 1311 Superior Ave., Cleveland 14. The new unit designed around the conventional Acro rolling spring is made with both single and double-throw contacts. Standard operating pressures are 3 to 5 oz. Rated at 15 amperes, 125 volts ac, and having overall dimensions of 2⅛ by 25/32 by ⅜ inches the switch is operated by a movement of approximately 1/16-inch



Screw-Clamp Connectors

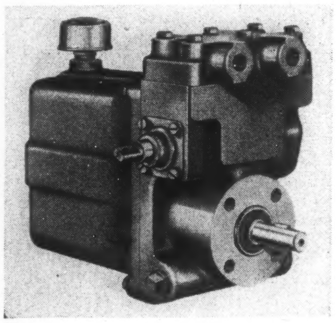
PROVIDING a single type of fitting capable of terminating practically any type of cable or cord in a standard ½-inch knockout box, a new series of connectors has been developed by the Gedney Electric Co., 1270 Sixth Ave., New York 20. New fittings are recommended for installation of rubber-jacketed cords, armored cable, etc., and are available in three types. Type C-15 has ½-inch thread and accommodates cord with diameter of from 3/16-inch to ½-inch. Type C-15S has ⅜-inch thread, accommodates cable sizes 14/2, 14/3 and 12/2. Type C-15L has ½-inch thread, accommodates cable sizes 14/3, 14/4, 12/2, 12/3 and 10/2.



Liquid Level Control

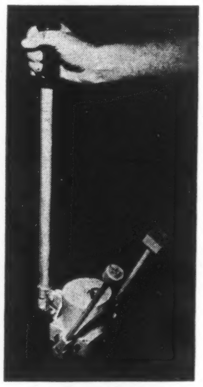
LIQUID-LEVEL control for all electrically-conductive liquids is now being marketed by Photoswitch Inc., 77 Broadway, Cambridge 42, Mass. Electrical contact with the liquid is made by stainless-steel mica-insulated probes. The Series 10 Photoswitch control contains no vacuum tubes and operates with low ac voltage in the probe circuit making electrolytic action impossible. It is recommended for control of such fluids as water, sodium chloride, milk, beer, copper nitrate and other acids, bases, and salts. The liquid to be controlled makes or breaks contact with the probe and transmits to the control a minute low-voltage electrical current. This current controls a power circuit which operates a relay to contact signal valves or pumps.

Hydraulic Unit



KNOWN AS the Power Pack, a new hydraulic unit introduced by Vickers Inc., 1430 Oakman Blvd., Detroit 32, combines several of the Vickers basic elements in one self-contained package. The unit is composed of a vane pump, relief valve, combinations of single and double operating valves, oil filter, air cleaner and oil tank. Weighing 45 lb, the unit can be attached to any power drive with V-belt, direct by chain drive or gears. Having a nominal pump delivery of 2, 3 or 5 gpm at 1200 rpm and 1000 psi, the power pack develops hydraulic pressure to actuate cylinders, motors, etc.

Hand-Power Hydraulic System



HYDRAULIC SYSTEM including in one unit a hand pump, 2 four-way selector valves, relief valve and reservoir is now available from Electrol, Inc., 85 Grand St., Kingston, N. Y. Standing only 4½ inches high and measuring 3½ by 4 inches at the base the unit weighs 5 pounds and can supply operating pressures up to 1500 psi. Power is supplied by hand pump although power pumps may be connected to ports provided. Hand pump delivery amounts to ⅞-cubic inch per cycle, and hydraulic pump delivery may be up to 1½ gpm.

JOHNSON BRONZE
SLEEVE BEARINGS
Give you EVERY worthwhile advantage

1 **LOW COST**

2 **PRECISION**

3 **QUIET**

4 **LONG LIFE**

5 **CORROSION RESISTANT**

6 **UNIT CONSTRUCTION**

7 **LOAD CARRYING CAPACITY**

8 **HIGH RESISTANCE TO SHOCK**

9 **LOW COEFFICIENT OF FRICTION**

10 **EASY TO INSTALL**

11 **CONFORMABILITY**

12 **NATION WIDE SERVICE**

LEADING engineers and designers prefer SLEEVE TYPE BEARINGS for numerous reasons. They have learned from experience the many distinct advantages gained when the right bearing is properly installed. In some applications, their reasons are strictly economic, such as low initial cost . . . quick assembly . . . easy replacement. It might be toughness . . . ability to carry heavy loads . . . to withstand shock and impact. Again it is quiet operation . . . smooth, silent performance. It may be precision . . . fine workmanship . . . adherence to close tolerance. It might be all of these characteristics . . . and more.

While these many factors govern the selection of the right *type* of bearing . . . the reasons for choosing the source of supply are even more important. To produce bearings that will deliver the greatest performance . . . for the longest period of time . . . at the lowest cost . . . requires experience, complete facilities, up-to-date equipment, and skilled employees. This is the kind of Bearing Service offered by Johnson Bronze to manufacturers of all types of equipment. Excellent service is available, now.

JOHNSON BRONZE COMPANY
525 S. MILL ST. · · NEW CASTLE, PA.

JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS

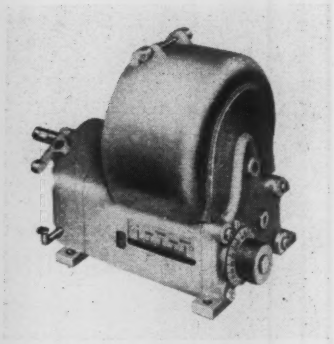
BRANCHES IN 18 INDUSTRIAL CENTERS

new parts and materials

Wire Screen

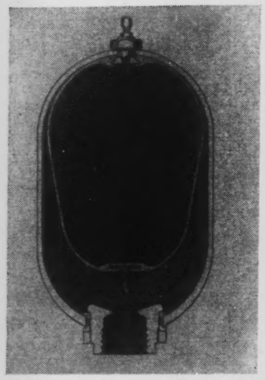
DESIGNED to provide maximum metal surface exposed to abrasive wear, a new screen now being offered by John A. Roebling's Sons Co., Trenton 2, N. J., is said to distribute wear evenly, increasing screen life up to 90 per cent. In operation the flat surface of the Roe-Flat screen permits an even, smooth flow across the screening surface, thus tending to eliminate clogging or blinding. New and unique methods have been developed for crimping, for bending edges and for welding. This is said to make possible aggregate wire screens with precision openings.

Control Device



DEVELOPED by the Counter and Control Corp., 2737 S. 28th St., Milwaukee 7, a new automatic electric switching control is useful for controlling the operation of signals, lights, relays, drives, motors, etc., where such components are required to function after a predetermined count measured in revolutions or strokes. The unit, known as the Cyclo-Monitor, is adjusted for a given cycle and, with the control established, it will accurately duplicate each succeeding cycle without further attention. The control may be actuated by either a rotating shaft or a reciprocating lever and may be adjusted to any number of input cycles between 1000 and 2000, or any even number between 2000 and 4000. Rotary driven model CMR may be operated safely at any speed up to 5000 rpm, while stroke model CMS operates successfully up to 1000 strokes per minute.

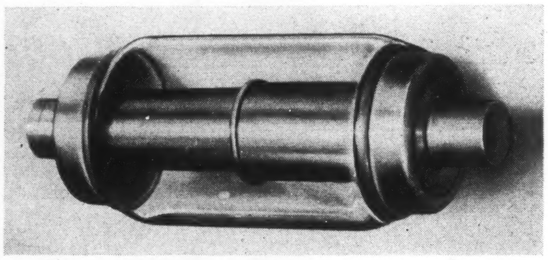
Hydraulic Accumulator



FULL-FLOW hydraulic accumulator of a new design is now available from Greer Hydraulics, Inc., 454 18th St., Brooklyn 15. The new unit has been tested under most severe operating conditions with satisfactory results. Volumetric efficiency of this design runs as high as 97 per cent with unrestricted flow up to 50 gpm, without appreciable pressure drop in systems operating at pressures as high as 3000 psi. Accumulator is a one-piece seamless steel shell enclosing an air bladder of synthetic rubber. Bladder incorporates an integrally-molded high-pressure automotive air valve on one end for preloading with air pressure, and an integral conical-shaped metal plug on the other end for sealing the shell at the end of the oil discharge cycle. Metal plug eliminates direct contact between outer bladder and outlet plug and thus precludes possibility of bag failure due to "pick-out" or tearing the bag at the outlet plug. Bladder will withstand operating temperatures from minus 40 F to plus 200 F and will retain its air discharge up to three months without attention from the operator.

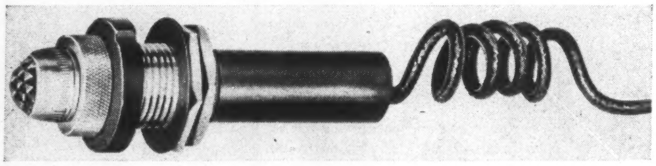
Capacitor

VACUUM CONDENSER rated at 30,000 volts maximum peak voltage and having a capacitance of 50 $\mu\mu$farads ±2 per cent has been placed on the market by Amperex Electronic Corp., 25 Washington St., Brooklyn. The capacitor has a maximum rms current rating of 65 amperes at 10 MC, and 40 amperes at 60 MC based on a maximum glass-to-metal seal temperature of 150 C. Maximum dimensions of the VC-50 vacuum condenser are 6.6 inches long and 2.5 inches diameter.



Pilot Light

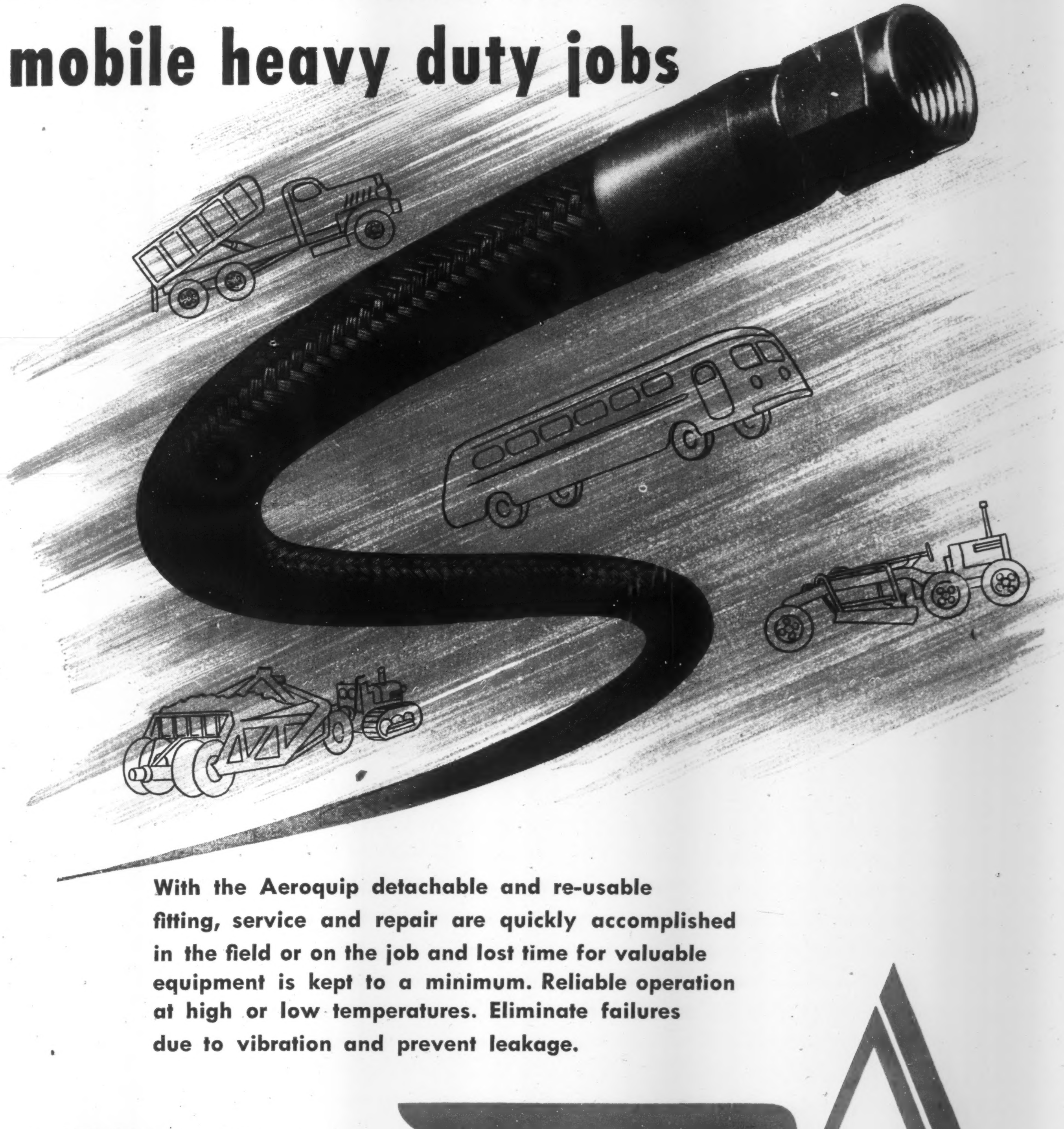
PILOT-LIGHT indicator incorporating a self-timing flasher which causes light to blink at a rate of 60 to 80 times per minute is now being offered by the Engineering Associates, 380 Main St., East Orange, N. J. Entire assembly including timer, lamp and housing is compact, measuring 3½ inches long with 1¼-inch flange diameter. It mounts on any panel in a single 13/16-inch diameter hole and has a theaded shank accommodating ¾-16 nuts. Current consumption of the complete unit is 200 ma and lamp operates on direct current to 32 volts or alternating current to 125 volts. On 125 volts ac, an external resistor of 500 ohms, 25 watts rating is required.



Welding Electrodes

DIRECT-CURRENT reverse-polarity electrodes for the welding of low-alloy cast steel or low-alloy high-tensile-strength rolled steels are available in three diameters—

AEROQUIP FLEXIBLE HOSE LINES serve all industrial and mobile heavy duty jobs



With the Aeroquip detachable and re-usable fitting, service and repair are quickly accomplished in the field or on the job and lost time for valuable equipment is kept to a minimum. Reliable operation at high or low temperatures. Eliminate failures due to vibration and prevent leakage.

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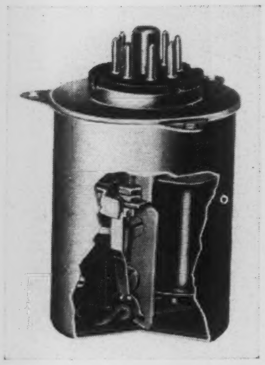
1/8 to 3/16-inch—from Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30. The electrodes, known as the AP-MO, are designed for butt and fillet welds in all positions and meet with the tentative AWS-ASTM specifications for iron and steel arc welding electrodes, classification E-7010.

Plug-In Relay



DEVELOPMENT of the new Bulletin 108 sensitive relay has been announced by the Ward Leonard Electric Co., Mount Vernon, N. Y. The new relay, of the plug-in type, is mounted on a standard octal plug base and enclosed in a cylindrical metal can hermetically sealed against moisture, gases, dust. The unit is provided with a normally-open single-pole contact having contact ratings of 2 amperes 24 volts ac or dc, 0.75 amperes 125 volts dc and 2 amperes 125 volts ac, with ac ratings given for noninductive loads at commercial frequencies. Relays are suitable for current-sensitive applications from 1.3 milliamperes to 0.54 amperes on direct current, and are applicable for operation on nominal voltages from 0.1 to 48 volts dc. Enclosing can measures 2 inches in diameter by 2 1/16 inches high, and no exposed wiring is present.

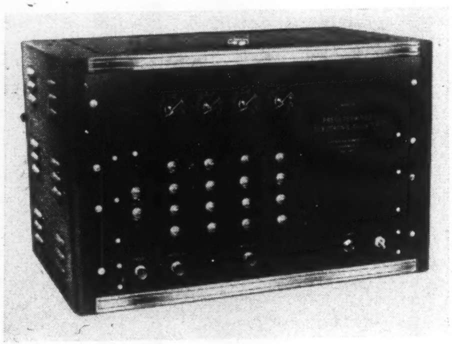
Safety Switch

TRUMBULL T ELECTRIC
ON
OFF

ADDED to the line of switches manufactured by the Trumbull Electric Mfg. Co., Plainville, Conn., a new Type D enclosed safety switch is rated at 30 amperes. The switch is compactly contained in a box measuring 4 ½ inches wide, 6 1/8 inches long and 3 1/4 inches deep. Switch is so designed that the pivoting lever may be padlocked in the off position to prevent opening of the switch or cover by an unauthorized person. It is available in four models, 125 volt; 3-pole solid neutral at 125/250 volts; 3-pole solid neutral with meter twist-out at 125/250 volts; and 3-pole solid neutral, 125/250 volts ac.

Electronic Counter

DESIGNED to meet the requirements of manufacturers concerned with high-speed counting, batching and packaging of parts, the new single-channel predetermined counter Model 140 is now obtainable from the Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y. Desired count is initially set up by means of dial switches located on front panel of the instrument. When predetermined number of items has been counted, unit actuates the control used to automatically stop or divert the flow of materials. Counter may be set to recycle automatically or manually by means of a remote control switch. When automatic reset is used the instrument will reset in two-thousandths of a second. Input to counter may be derived from a photoelectric beam, switch, shaft rotation, reciprocating member, electromagnetic field disturbance and many other actions. Output is from an ultra-high-speed double-pole single-throw relay readily adaptable to solenoid actuation of existing controls.

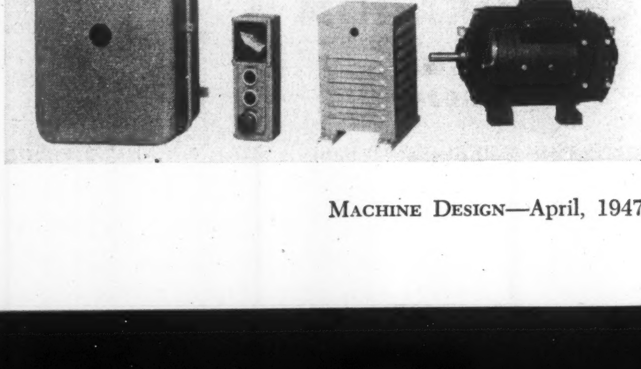


Flexible Metal Hose

FULLY-INTERLOCKED metallic flexible hose one eighth of an inch in diameter is now being made by the Pennsylvania Flexible Metallic Tubing Co., 72nd and Powers Lane, Philadelphia 42. The new tubing is available in bronze, steel or alloys, and retains all properties of the larger sizes. It is used as a protective casing for capillary tubes, for covering wires, etc.

Variable-Speed Drive

ELECTRONIC variable-speed drive having a 100:1 speed range and flat speed-regulation curve is now available. The compact device known as the Servotron consists of four units: A transformer for connection to the ac power supply; a control unit comprising rectifier, control and protective circuits; a dc motor having inherent good speed-torque characteristics; and a control station with forward reverse and stop pushbuttons as well as a speed-setting potentiometer control knob. The drive, manufactured by the Industrial Electronics Division of Raytheon Manufacturing Co., Waltham 54, Mass., is available in a line ranging in output from 1/20 to 10 horsepower.



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FABRICATED
"O" RINGS

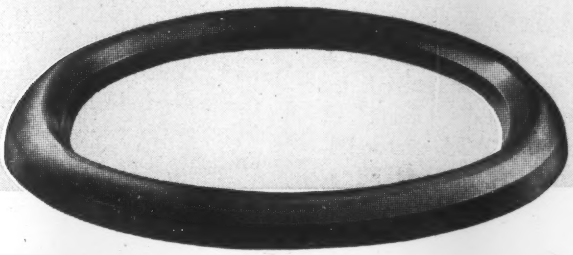
NOT JUST ONE TYPE OF PACKING

-BUT FOUR-

plus a design service only Houghton can render

We're partial to packings, but we're impartial as to type, except that we'll recommend the most efficient for your job. Houghton makes four popular styles shown here, and provides an engineering service already familiar and helpful to design men the country over.

E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa.



HOUGHTON'S

VIM LEATHER AND VIX-SYN

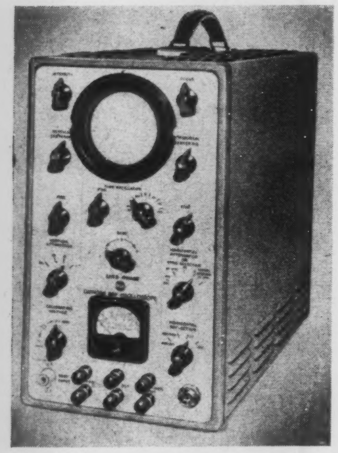
PACKINGS

engineering dept equipment

High-Speed Printer Developer

PRINTER AND DEVELOPER designed for large-volume production of cut sheets up to 42 inches wide is now being manufactured by Charles Bruning Co., Inc., 4754 Montrose Ave., Chicago 41. With the new machine, prints are produced in volume at speeds up to 30 feet per minute. The device, known as the Bruning Model 91 BW Volumatic Printer-Developer, will print light, regular, or card-weight paper prints with black or colored lines on white background, green tinted background, transparent paper prints, etc. It requires only one operator.

Oscilloscope



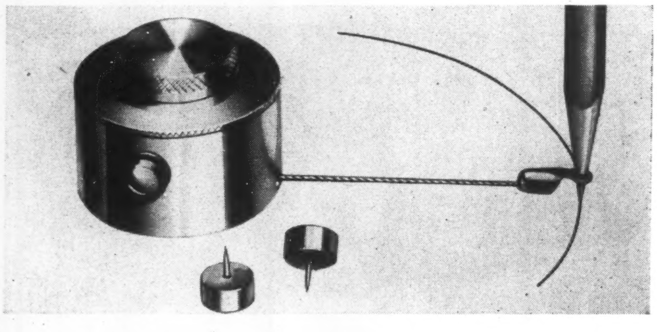
PORTABLE three-inch oscilloscope is now being manufactured by the Radio Corp. of America (RCA Victor Division), Camden, N. J. This new general oscilloscope, RCA Type WO-79A, makes possible the accurate measurement and display of frequency components up to six megacycles in transient and pulsed voltages of the order of one microsecond. The instrument is designed to achieve detailed observation and accurate measurement of the extremely short, sharp-fronted pulses produced by many modern electronic devices. The major electrical components of the oscilloscope include calibrated horizontal and vertical input attenuators, high-gain horizontal and vertical amplifiers, a synchronized amplifier, a time-base oscillator and sweep generator, and intensifying amplifier. Centering controls on the oscilloscope permit expansion of the wave-form under test over a distance equal to twice the diameter of a screen without visible distortion of the image.

Floating Triangle

OF CLEAR, NONINFLAMMABLE, nonwarping, nonshrinking plastic material, a new line of triangles now being offered has raised edges giving improved contact with T-square, preventing triangle from slipping under it. The line, manufactured by Instrumaster Industries, Inc., Greenwich, Conn., comprises 45-degree and 30/60-degree styles in sizes from 4 to 12 inches. Triangles are provided with integral buttons projecting on both sides so that the triangle rests only on these buttons and is kept 0.020-inch from surface. This prevents smudging of pencil lines and at the same time facilitates inking. The 30/60 triangles have a 45-degree interior opening while 45-degree units have a 30/60 cut out.

Beam Compass

INSTRUMENT to aid in drawing ellipses, spirals and circles up to 12 feet in diameter is now available. This compass consists of a stretch-proof linen line housed in an aluminum reel. It is provided with a special push pin which is pressed into drawing board to locate and support reel. When line is drawn out to desired radius it is automatically held in this position for drawing arc. Manufacturer is the Stewart-Jackson Instrument Co., 215 W. Seventh St., Los Angeles 14.

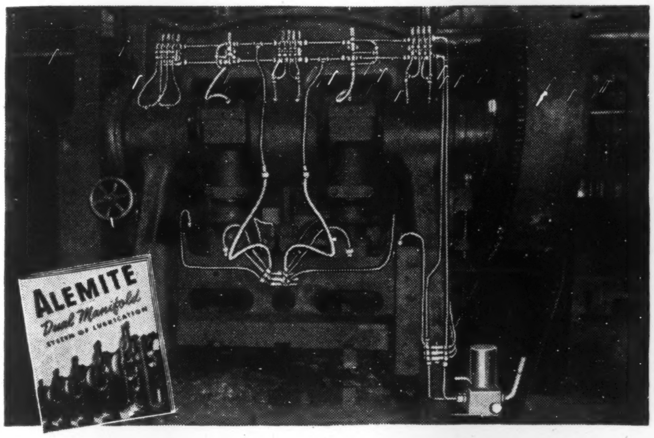


NOW ADD "MORE PRODUCTIVE TIME" TO YOUR MACHINE'S PERFORMANCE

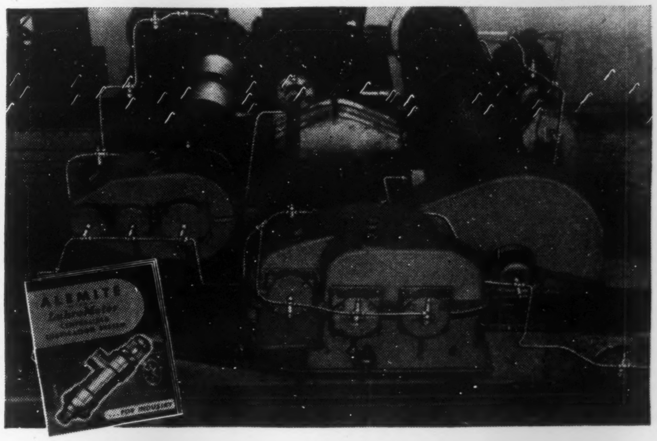
Here are 3 Alemite Centralized Lubrication Systems to Help You Meet Your Operational Problems!

No *single* lubrication system has ever been developed that will meet the operational needs of *all* types of machines. But, whether your machines are big or little, simple or complex, it will pay you to investigate the special advantages of each Alemite Centralized Lubrication System. Thousands of these systems are performing satisfactorily in every kind of industry—reducing bearing failures, eliminating human error, adding More Productive Time per machine, cutting costs as they boost production.

ALEMITE DUAL PROGRESSIVE SYSTEM is ideal where excessive dirt and moisture is a problem. The system is completely enclosed, fully hydraulic. Each valve delivers a large or small metered amount of oil or grease to two bearings. The lubricant flows *progressively* to each bearing while the machine is producing . . . an indicator at the point of introduction signals when lubrication is completed. Designed for manual or automatic operation. Send for descriptive booklet.



ALEMITE DUAL MANIFOLD SYSTEM—a heavy duty system for use where large amounts of oil or grease are required, such as in steel mills, foundries, forge shops, steel fabricators, etc. The system is fully hydraulic . . . each valve delivers a metered amount of lubricant to two bearings while the machine is operating. An indicator at the central point where lubricant is introduced signals when job is done. Available for both manual or automatic operation. Send for descriptive booklet.



ALEMITE LUBROMETER SYSTEM . . . applicable to heavy or light machines, precision machines, outdoor installations. It is a single lubricant line, hydraulically operated system for oil or grease. Valves can be installed in or near each bearing. A measured amount of lubricant is conveyed to each bearing from one central point while machine operates. An indicator signals when job is done. Choice of manual or automatic operation. Send for descriptive booklet.

ASK FOR ANY TECHNICAL HELP. Our highly trained Alemite Lubrication Specialists will gladly work with you on lubrication problems. Ask for interesting demonstration of Alemite Systems right at your desk with transparent working models. Alemite, 1804 Diversey Parkway, Chicago 14, Ill.

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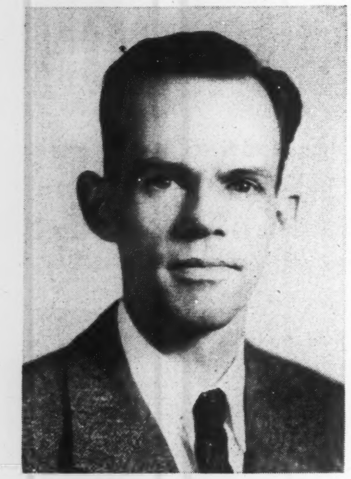
Centralized Lubrication Systems

Another Product of
STEWART WARNER

Howard F. Doll



John F. Fisher

Preston R. Bassett

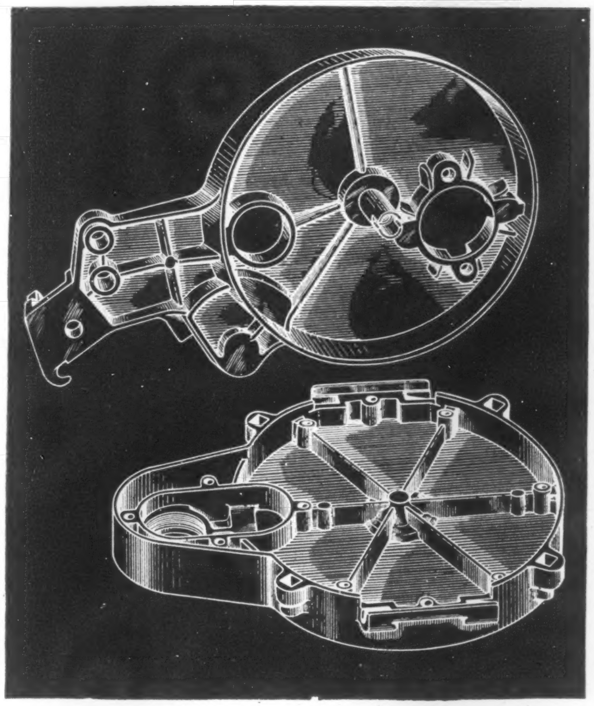
MEN . . . of . . . machines

HOWARD F. DOLL, recently appointed vice president in charge of engineering, Victor Electric Products Inc., had been chief engineer for the company since 1945, devoting his efforts to the design of electric fans, ventilators, exhaust fans and shaded-pole motors produced by that company. He obtained considerable previous experience along this line with the Dumore Electric Co. where from 1940 to 1944 he served as chief engineer in charge of all phases of engineering on universal motors, aircraft motors, appliances, and tools. From 1933 to 1940 he worked as sales engineer in the Chicago office of General Electric Co., in its fan division, devoting his time to the application of fractional-horsepower motors to appliances and devices. Prior to 1933 he was connected with General Electric Co. in its fractional-horsepower motor division in Fort Wayne. He joined this division in 1929, immediately upon graduating with a bachelor of science degree in electrical engineering from the University of Notre Dame.

JOHN F. FISHER as chief engineer of Harrington Mfg. Co., Mansfield, O., will devote his future efforts to designing buffets and food equipment for all the major airlines as well as many of the aircraft manufacturers. A graduate of the University of Maryland and of the Massachusetts Institute of Technology where he received his master's degree in mechanical engineering, Mr. Fisher became connected in 1935 with a heating and air conditioning contractor and worked until 1940 as chief engineer for residential air conditioning and commercial refrigeration. He then joined the engineering staff of American Airlines as project engineer of the accommodations group which dealt with interior items of the airline's fleet of DC-3's and later conversion of the DC-4's and DC-6's. The work included design and maintenance engineering of cabin liners, food equipment, oxygen, heating, ventilation and supercharging. Mr. Fisher then resigned from this position to take his new post as chief engineer of Harrington Mfg. Co.

PRESTON R. BASSETT, president of Sperry Gyroscope Co. Inc., has been elected president of the Institute of Aeronautical Sciences for 1947. Mr. Bassett is well-fitted to head the Institute since his interests in aeronautical sciences have been many and varied. As early as 1915 he worked on the development of some of the first flight instruments to be carried by airplanes. He also was one of the pioneers to be interested in passenger comfort, developing the first successful system of sound-proofing. During the

PRACTICAL CONSIDERATIONS IN DIE CASTING DESIGN



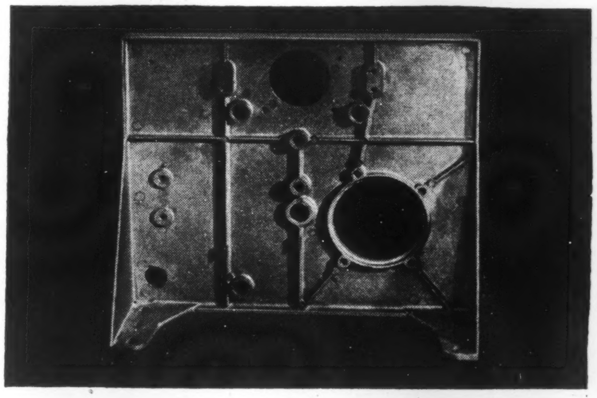
RIBS OR FINS PROVIDE MANY ADVANTAGES

In designing die castings, do not overlook the advantages to be gained through the judicious use of ribs or fins. In addition to providing added strength and stiffness, ribs can:

1. Minimize distortion
2. Reduce weight through the use of thinner sections
3. Promote the proper flow of metal in the die
4. Distribute stresses over larger areas

Several zinc alloy die castings are illustrated here to indicate the variety of ways in which ribs are employed. First, consider the above drawing. These two castings are employed in lawn mower assemblies where strength is a primary consideration. The use of heavy ribs and peripheral flanges (which are ribs in effect) provide the necessary strength with a minimum amount of metal and weight. Fairly light bosses are employed since they are strengthened by the ribs and flanges.

Another interesting example is the angle bracket for an aviation testing device shown in the photograph below. This casting is kept quite light and very rigid by good ribbing and, here again, the ribs provide added strength for bosses.



ALLOY SELECTION

Good die casting design is of no avail unless the proper alloy is selected. Furthermore, it is imperative that any alloy used in die casting production be carefully formulated with respect to every element involved to insure maximum mechanical properties and dimensional stability. If a zinc alloy is used, your die caster should provide one of those shown in the table below. These alloys are covered by specifications of the American Society For Testing Materials and the Society of Automotive Engineers.

Composition of Zinc Alloys For Die Castings

Composition* % by Weight	ZAMAK†-3 A.S.T.M.-XXIII S.A.E.-903	ZAMAK†-5 A.S.T.M.-XXV S.A.E.-925
Copper	.10 Max.	.75 to 1.25
Aluminum	3.5 to 4.3	3.5 to 4.3
Magnesium	.03 to .08	.03 to .08
Iron, Max.	.100	.100
Lead, Max.	.007	.007
Cadmium, Max.	.005	.005
Tin, Max.	.005	.005
Zinc	Remainder	Remainder

*Composition as provided in A.S.T.M. and S.A.E. Specifications. The Zamak alloys meet these specifications but are held within closer limits as to composition.

† A trade mark (registered in the U. S. Patent Office) identifying the zinc alloys developed by The New Jersey Zinc Company and used in the die casting industry.

For additional data on die casting design ask us—or your die casting source—for a copy of the booklet "Designing For Die Casting".

Send for your copy ➡

DESIGNING FOR DIE CASTING

ZINC
FOR DIE CASTING ALLOYS

The New Jersey Zinc Company, 160 Front St., New York 7, N. Y.

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

first world war he was responsible for the development of a high-intensity antiaircraft searchlight. After the war he helped to establish the air mail by setting up the first night airway and developing both beacons and airport floodlights. The blind-flying instruments, the gyro-horizon and directional gyro, now considered standard equipment on transport and military planes, were developed under his direction as was the Sperry gyropilot for automatic flying.

Mr. Bassett was graduated from Amherst College in 1913 with an A.B. degree, and subsequently an M.A. He also did postgraduate engineering work at Brooklyn Polytechnic Institute before joining the Sperry Gyroscope Co. Inc. in 1914 as research engineer. In 1929 he was appointed chief engineer for the company, and vice president in 1932. His election as general manager came in 1914, and in November, 1945 he was made president, the position he now holds.

◆

Walter Van Voorhees is now connected with Wickes Bros., Saginaw, Mich., as engineering designer. He had been at the El Segundo plant of Douglas Aircraft Co. Inc.

◆

Lee C. Daniels recently has been appointed chief engineer of Towmotor Corp., Cleveland.

◆

T. E. Orr, vice president and general manager of Plastic Engineering Inc., has been elected president of the Society of Plastic Engineers Inc. for 1947.

◆

C. A. Wiken, chief engineer of the Delta Manufacturing Division of the Rockwell Mfg. Co. for the past eight years, has been promoted to the position of vice president in charge of engineering for the Rockwell company. He will co-ordinate the engineering activities of the various divisions and subsidiaries and supervise the standardization of engineering procedures and materials. His previous background includes many years of design and administrative engineering work with Greenlee Bros. Machine Co., Falk Corp., and Fay-Egan Co.

◆

Arthur McCutchan in his new capacity as senior research engineer of the product engineering and research department of Tube Turns Inc., Louisville, Ky., will be associated with the chief research engineer, **A. R. C. Markl**, formerly mechanical engineer in charge of the pressure equipment and materials division of the M. W. Kellogg Co. Mr. McCutchan had been associated for twenty years with the engineering division of Detroit Edison Co.

◆

Paul Huber has been named director of research for Willys-Overland Motors Inc., Toledo, O. He had been assistant director of the General Motors Proving Ground at Milford, Mich. **Robert E. Busey**, formerly executive engineer in charge of new developments at White Motor Co., has been placed in charge of truck engineering for the Willys-Overland organization. Other engineering changes include: **Walter F. Benning** technical assistant to D. G. Roos, vice president and director of engineering, and in charge of passenger car engineering; **Leo O. Burt**, passenger car chassis engineer; **Charles Cuma**, engine development engineer; **F. L. Mills**, chief draftsman of the chassis division; **Charles E. Schutte**, chief engineer of the Body division, with **A. C. Smith** as assistant chief engineer; **Charles E. Barber**, body engineer in charge of mechanical engineering; and **Fred M. Baker**, chief draftsman of the body division. **E. C. DeSmet** is assistant to the vice president in charge of engineering and will have charge of design, styling and surface development.

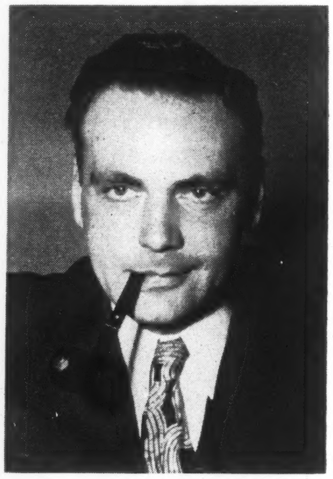
◆

Raymond L. Collier, formerly executive secretary of Steel Founders' Society of America with which organization he had been identified for more than eighteen years, has been appointed executive vice president of Gray Iron Founders' Society Inc.

◆

William L. Hunter, formerly chief engineer, has been made general manager of Northern Equipment Co., Erie, Pa. **Harold A. Schlieder**, associated with the company since 1936, succeeds Mr. Hunter as chief engineer. **Francis W. Bunting** has been appointed assistant chief engineer.

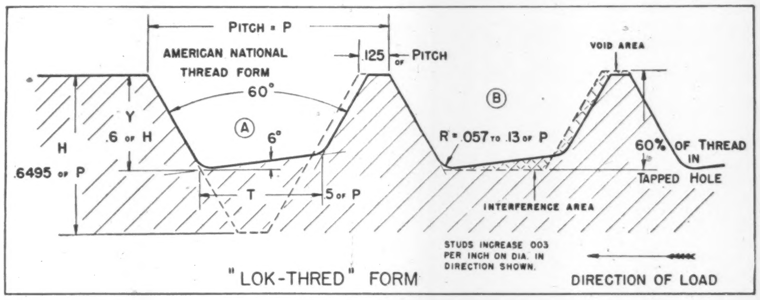
◆



KENNETH H. BARNES, chief engineer of American Foundry Equipment Co., Mishawaka, Ind., has been connected with that company since 1936. He started in the engineering department on proposal drawings and design engineering. With the heavy demand for specially designed equipment to perform many different jobs during the war, Mr. Barnes was transferred to the sales department at that time and handled the sale of the specialized Wheelabrator equipment for five years prior to becoming chief engineer. He is a recognized authority on shot peening, having written many technical papers on the subject.

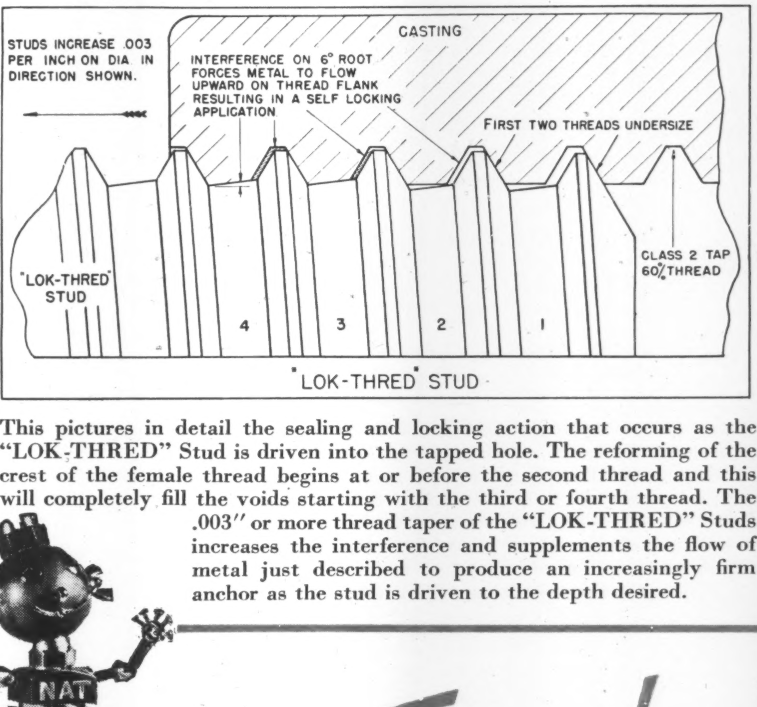
CHALMER R. CLINE has recently returned to the American Foundry Equipment Co. and will serve in his new position as engineering assistant to the president. Prior to five years with the army as Major in the Ordnance Industrial Service, Mr. Cline served in many capacities for various companies. As sand conditioning engineer he worked for National Tube Co., and as machinist, for Thew Shovel Co. He also has been engaged in industrial gas research for the American Gas Association, and has done some sales engineering work for the American Mfg. Co. In addition, he has

"LOK-THRED" STUDS BECOME *TIGHTER* IN SERVICE


PITCH = P
AMERICAN NATIONAL THREAD FORM
.125 OF PITCH
VOID AREA
60°
Ⓐ
Ⓑ
6°
Y
.6 OF H
H
.6495 OF P
T
.5 OF P
R = .057 TO .13 OF P
60% OF THREAD IN TAPPED HOLE
INTERFERENCE AREA
STUDS INCREASE 003 PER INCH ON DIA. IN DIRECTION SHOWN.
DIRECTION OF LOAD

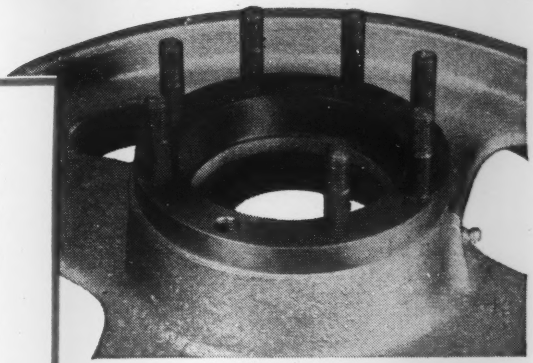
"LOK-THRED" FORM

The heavy black line illustrates the "LOK-THRED" form superimposed on the American National Thread form indicated by the dotted lines, position A picturing the comparison in the male thread of each. Position B diagrams the action that occurs as the male "LOK-THRED" enters the 60% American National Thread tapped hole. The metal from the crest of the female thread (shown as "interference area") is caused to flow along the helix angle of the male "LOK-THRED" completely filling the void between the flanks of the two mating threads (indicated as "void area"). This creates a positive seal and firmly anchors the stud.


STUDS INCREASE .003 PER INCH ON DIA. IN DIRECTION SHOWN.
CASTING
INTERFERENCE ON 6° ROOT FORCES METAL TO FLOW UPWARD ON THREAD FLANK RESULTING IN A SELF LOCKING APPLICATION
FIRST TWO THREADS UNDERSIZE
"LOK-THRED" STUD
CLASS 2 TAP 60% THREAD
4
3
2
1

"LOK-THRED" STUD

This pictures in detail the sealing and locking action that occurs as the "LOK-THRED" Stud is driven into the tapped hole. The reforming of the crest of the female thread begins at or before the second thread and this will completely fill the voids starting with the third or fourth thread. The .003″ or more thread taper of the "LOK-THRED" Studs increases the interference and supplements the flow of metal just described to produce an increasingly firm anchor as the stud is driven to the depth desired.

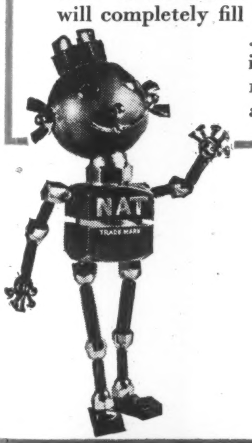


These diagrams show why "LOK-THRED" Studs lock more securely than American National Threads, and why they are chosen for such applications as this differential axle driving flange used by the Silent Hoist & Crane Company on their "Krane Kar".

Notice in the diagrams the 6° angle at the root of the "LOK-THRED" which carries the entire normal load under high compressive pre-stress. This avoids the chief weakness of standard interference fit, which tends to cause a bursting or splitting action by placing the metal of the receiving thread under shear.

10 ADVANTAGES OF "LOK-THRED" STUDS

1. **Lock securely and become tighter in service.**
2. **Have much higher fatigue limits than studs with conventional threads.**
3. **Stronger in both tension and torsion than ordinary American National Threads.**
4. **Carry entire normal working load on 6° angle at root of thread under high compressive pre-stress.**
5. **Modified American National Threads permit use of standard tools.**
6. **Re-usable and on any re-application less than one-half additional turn brings torque back to its original installation value.**
7. **Do not require selective fits.**
8. **Do not gall when being driven nor fret in service.**
9. **Act as dowels and taper pins.**
10. **Seal positively and eliminate added bosses and blind tapping.**


NAT
TRADE MARK

National
HEADED AND THREADED
PRODUCTS

Write for "LOK-THRED" Booklet for more information.

THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

taught heat treating at the University of Cincinnati, physical chemistry at the Lorraine Institute of Arts and Sciences and industrial furnace design at the John Huntington Institute.

◆

James L. Straight, Wartime Committee Coordinator for the Aircraft War Production Council, has been appointed manager of the Western Region of the Institute of the Aeronautical Sciences.

◆

James P. Henderson is the new chief engineer and general manager of the Gotham Instrument Co. Inc. For nineteen years Mr. Henderson had been connected with the C. J. Tagliabue Co. in the engineering department, research and development and as division manager. Also for several years he was engaged in independent development of mechanical, electrical and electronic instruments.

◆

Frank B. Lounsberry, vice president in charge of methods and processes, has succeeded **Vere B. Browne** as vice president and technical director of Allegheny Ludlum Steel Corp. Mr. Browne has retired.

◆

Dr. Winton I. Patnode has been placed in charge of the Hanford Branch of the General Electric Research Laboratory at Richland, Wash.

◆

Edward M. Sharer has been named transmission engineer for General Motors Corp., Allison Division, Indianapolis.

◆

Elmer J. Barth, previously chief draftsman, has been promoted to chief engineer of mechanical transmissions for Spicer Mfg. Div. of Dana Corp., Toledo, O.

◆

Albert A. Maynard recently was named assistant chief engineer of the Chevrolet-Cleveland Division of General Motors Corp., Detroit.

◆

Earl G. Gunn, formerly vice president in charge of engineering for Fram Corp., Providence, is now consulting engineer for the corporation.

◆

Robert A. McCloud is now design engineer with the Food Machinery Corp., Anderson Barngrover Division, San Jose, Calif. He had been chief engineer of Bacon Vulcanizer Mfg. Co., Oakland, Calif.

◆

W. H. Williams has resigned as president of The Clark Controller Co. to become chairman of the board. One of the founders of the company, he served for twenty years as vice president and for the past two years as president. **Robert H. Hoge** with ten years' service with the company in various capacities from application engineer through vice president and general manager, succeeds Mr. Williams as president.

◆

Dr. Charles M. Slack, who developed an electronic tube making possible millionth-of-a-second x-ray exposures, has been appointed director of research for the Westinghouse Lamp Division, succeeding **Dr. Harvey C. Rentschler**, director of lamp and electronic tube research for the past 30 years. Dr. Rentschler, who is approaching retirement, will devote himself to completing certain research projects.

◆

Donald E. Cressy has been named design engineer of McDonnell Aircraft Corp. Formerly he had been aeronautical drafting engineer.

◆

L. H. Grisell, since 1942 chief engineer of Kermath Mfg. Co., Detroit, was elected president, director and treasurer of the company.

◆

Howard Jarmy recently has been appointed assistant chief engineer of the Muskegon Motor Specialties Co. He formerly had been in the U. S. Army Air Corps.

◆

Clifford O. Kiser, previously engineer in charge of tractor design for J. I. Case Co., Rock Island, Ill., has been promoted to the post of assistant chief engineer.

◆

Leonard O. Mjolsnes, assistant development engineer of Baldwin Locomotive Works, Eddystone, Pa., has been named development engineer.

◆

Lloyd D. Yates has accepted the position of instructor of engineering, drawing department, Ohio State university. He has just left the U. S. Navy.

◆

Clifford J. Leisey, who has a background of over twenty-seven years in the aircraft industry covering administrative phases of aircraft engineering as well as design, theoretical and manufacturing fields, is now chief administrative engineer of Willys-Overland Inc., Los Angeles.

◆

A. E. Kolbe, formerly design engineer, has been promoted to assistant chief draftsman of Chevrolet Motor Division of General Motors Corp., Detroit.

◆

J. R. Marchant has accepted a position with the Kaiser-Frazer Corp. at Willow Run, Mich., as chief draftsman for electrical design.

◆

Herbert H. Thurston has resigned from Bendix Aviation Corp. in order to become design engineer of the lift truck division, Ross Carrier Co., Benton Harbor, Mich.

◆

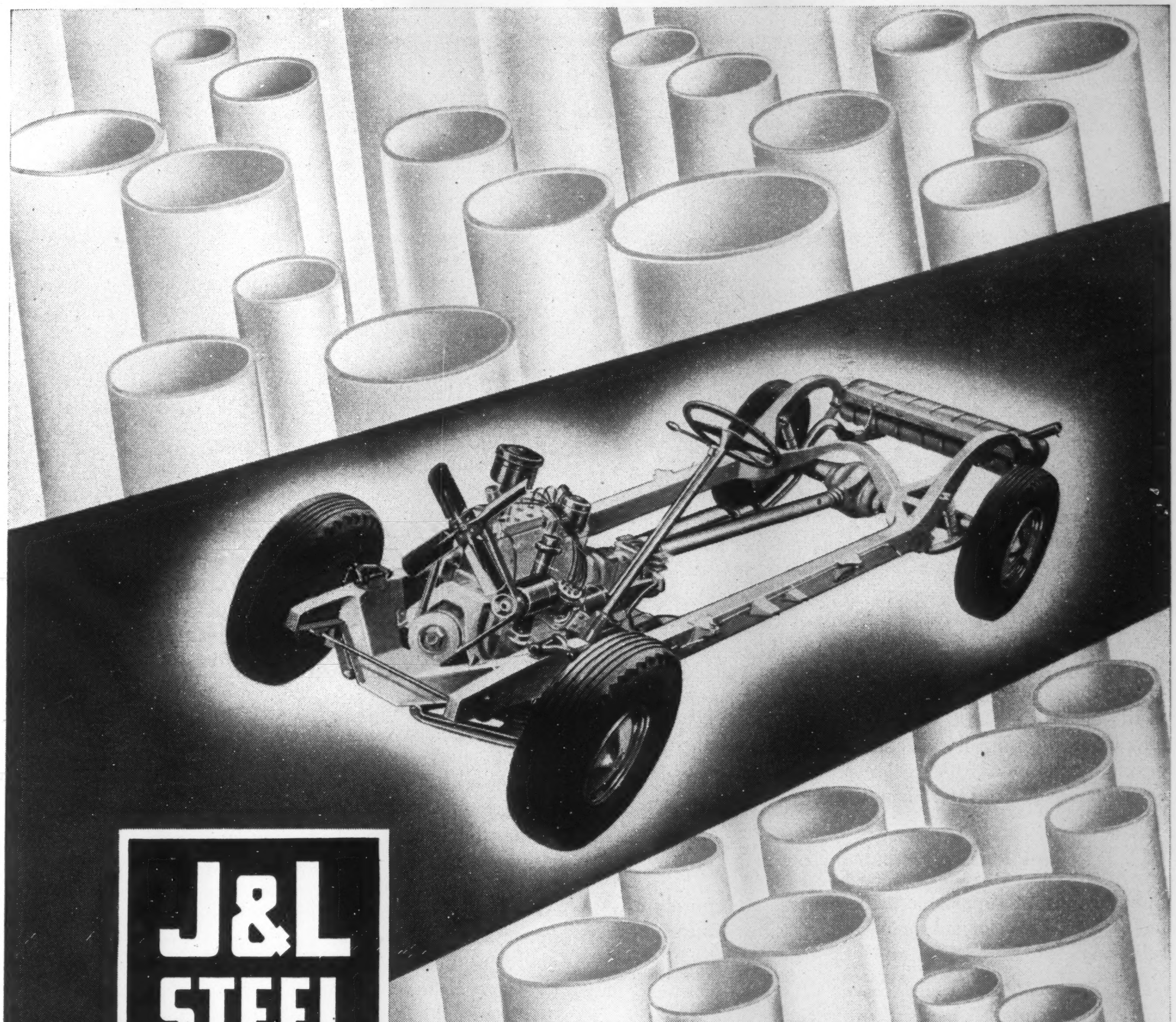
Arthur C. Bloomer has resigned as machine and tool designer for Vulcan Bearing Machine Co., Dallas, and is now associated with Universal Corp. as chief draftsman.

◆

William W. Dunnell Jr. has resigned as chief engineer of Rivett Lathe & Grinder Inc., Boston, to become a member of the engineering staff of the Division of Industrial Cooperation of the Massachusetts Institute of Technology.

◆

Louis Gerard Pacent, well known engineer and pioneer in radio and electrical communication, recently was awarded the War Department Certificate of Appreciation in recognition of his engineering services to the Signal Corps.



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Design Abstracts

Aerodynamics of Supersonic Flight

UNTIL recently, study of the motion of bodies with velocity faster than sound belonged to the realm of ballistics. As a matter of fact, when the science of modern aerodynamics developed a few decades ago, most theories were based on the assumption that air can be considered an incompressible fluid. It was shown that the error in the computation of air forces produced by the motion of an airplane is about one half times the square of the ratio between flight velocity and sound velocity (760 mph at normal conditions). This ratio is known as Mach number. If the flight velocity is 150 mph, the error is about 2 per cent. As flight velocity of airplanes increased, it became necessary to consider the so-called "compressibility effect", which could no longer be neglected as it was at moderate speeds.

A few years ago, the very large drag at velocities near to sound velocity (i.e., for Mach numbers near one), led to the belief that sonic velocity is not penetrable. This is now being proved fallacious as new propulsion devices are developed to produce very large thrust, and new design concepts are evolved to reduce the drag.

Three Rules Govern Supersonic Flight

Basic rules of supersonic aerodynamics are entirely different from those of subsonic aerodynamics. These new rules are:

> 1. *Forbidden signals*: Since a slight pressure change propagates in the air with sound velocity, it is evident that the effect of pressure changes produced by a body moving with a speed faster than sound cannot reach points ahead of the body. As one may say, the body is unable to send signals ahead. It is seen that there is a fundamental difference between subsonic and supersonic motion. In the case of subsonic motion, for example the uniform level flight of an airplane, the pressure signal ahead proceeds with sound velocity minus flight velocity relative to the airplane, whereas a signal backward travels with a speed equal to the sum of the flight and sound velocity. Although the distribution of the effects is not symmetrical, for practical purposes every point in the space has been reached by a signal. As can be easily seen, this is not the case in supersonic flight, which leads to the second rule:
>
> 2. *Zone of action and zone of silence*: If a point source of sound is at rest, the pressure effect spreads as spherical surfaces of even spacing. If a point source is moving faster than sound, then all action is restricted to the interior of a cone which includes all spheres of pressure effects. The outside of this cone can be called the zone of silence. It is easily seen that the trigonometrical sine of the half vertex angle of the cone is equal to the reciprocal value of Mach's number. This angle is called Mach's angle. The cone which separates the zone of action from the zone of silence is called Mach's cone.
>
> 3. *Concentrated action*: This rule expresses another characteristic difference between subsonic and supersonic motion, which concerns the distribution of the pressure effect in the space relative to the moving body. In the subsonic case it is found that the pressure effect not only decreases with increasing distance from the source, but is also dispersed in all directions. In the case of a body moving with supersonic velocity, the bulk of the effect is concentrated in the neighborhood of the surface which limits the zone of action.

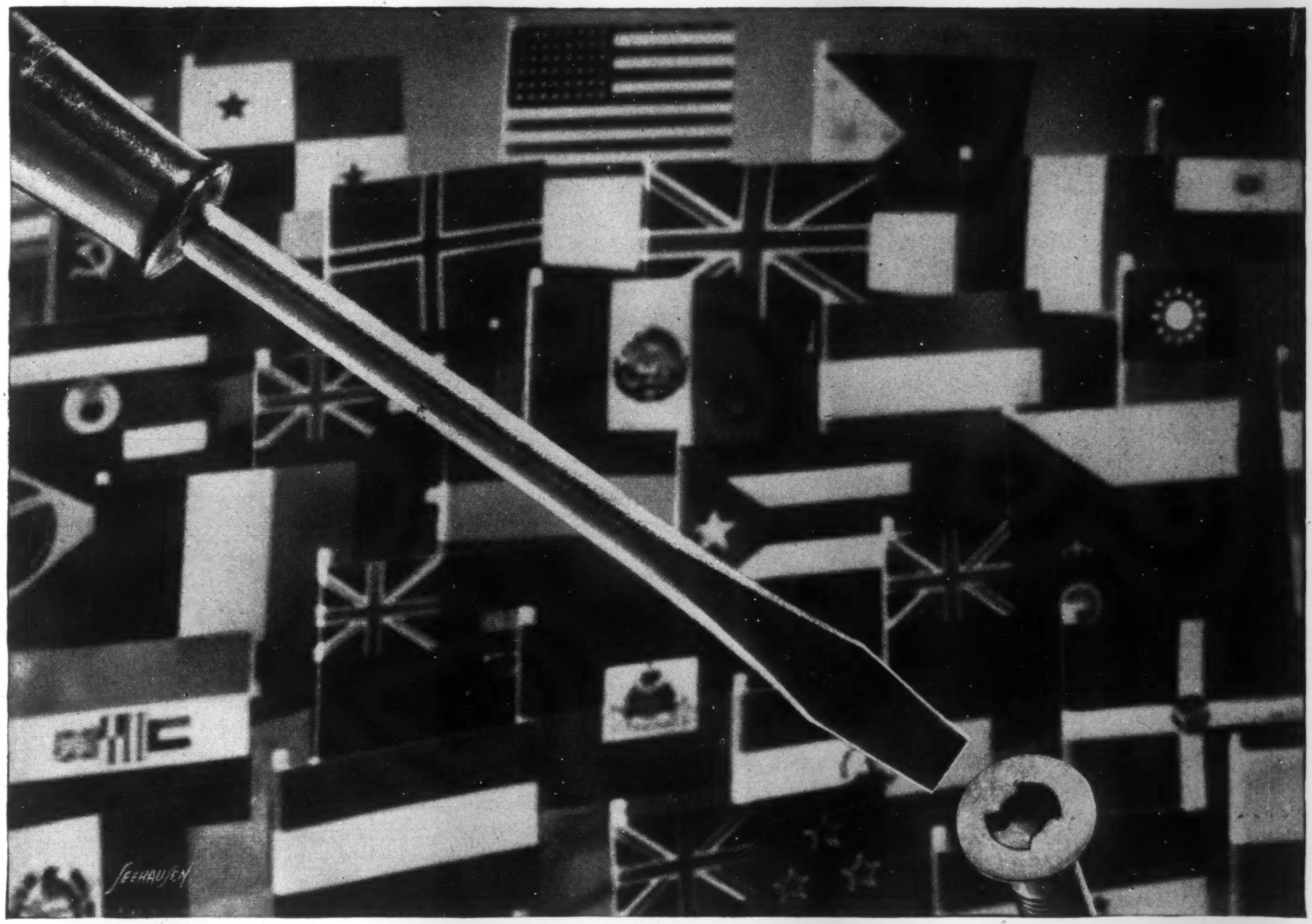
With these basic rules one can understand the mechanism of drag formation and the mechanism of lift production. The drag can be divided into wave drag and induced drag. Wave drag is characteristic of supersonic flow, and represents the energy expended in creating the concentrated disturbance on the surface of Mach cones. Induced drag is the result of the production of lift and is represented by the kinetic energy of the downward motion of air mass created to counterbalance the lift force. Therefore, induced drag is present also in subsonic flow. It is the wave drag that is troublesome and raises the overall drag of a supersonic aircraft. By sweeping back the leading edge of the wing, the wave drag can be greatly reduced, and the overall lift-over-drag ratio, or aerodynamic efficiency of the wing, can be increased to a value comparable with the highly efficient subsonic wings. This opens the door to supersonic flight.—*From the tenth annual Wright brothers memorial lecture, presented by Theodore von Kalman, California Institute of Technology, at a meeting of the Institute of Aeronautical Sciences, in Washington, D. C.*

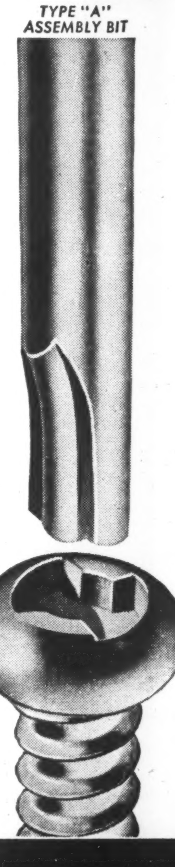
Measurements as an Aid to Design

FEW designers are ever provided with certain facts that should form the real starting point of design, namely the values of the measured loads that the structure encounters in service. These facts can only be had by actually measuring the loads which, prior to certain recent developments, were mighty hard to measure so as to include frequency, amplitude, impacts, occasional overloads, and superimposed vibrations. Now the job is not too difficult using modern electric strain gages and oscillographs.

Usual practice has been to assume these loads. Engineers seemed not too unhappy about starting with an assumption upon which they piled their other analytical design assumptions (always on the safe side) believing that one wrong guess might counteract another. However, this usually ended in an overstrong chain with a few weak links, so the strength of the chain could be rated only at the strength of the weakest link.

This was all right until we became serious about our





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Accordingly, the logical design of CLUTCH HEAD screws for operation with any flat blade is important to the manufacturer whose reputation is staked upon the peak performance of his product in the field ... upon the ease and readiness with which immediate adjustments can be made.

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CLUTCH HEAD is the one and ONLY modern screw specifically engineered to give you the dual advantage of safer, higher speed assembly operation with the Type "A" Bit ... plus simplified field service with common screwdriver control.

CLUTCH HEAD has unmatched features that contribute to safer, faster, lower-cost production. You may check these personally by sending for assortment of screws, sample Type "A" Assembly Bit, and illustrated Brochure ... to come by mail.

CLUTCH HEAD
SCREWS

UNITED SCREW AND BOLT CORPORATION

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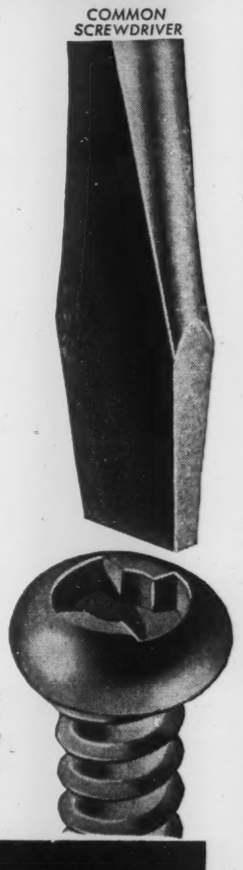


military aircraft design and then a sharp penalty was applied. The edict then came down from above—use all the elastic strength in the materials that can possibly be had, use proof loads that run close to design loads and do not speak of factors of safety. Make structures alleviate local high stressing by local yielding and don't pass high levels on through rigid parts to some weaker point. Don't let dynamic stress raisers weaken the load-carrying capacity of a statically strong structure, in other words, smooth out stress gradients, and remember that a structure which is to be used dynamically cannot be certified by a static test alone. Measure service loads, in fact, base all strategy on measurement of everything. So a new type of engineer had to be created, as well as a new set of testing tools, a new way of thinking and a new testing technique. It all worked out remarkably well during the war.

Design Improvement Procedure

To be specific on design improvement, the procedure varies somewhat but generally it follows this sequence.

I. *Measurement of Service Loads*: Put the existing structure through its paces in service, measuring loads encountered under worst operating conditions. Strain gages and accelerometers connected into 12-element oscillographs recording on moving film is a usual method.

II. *Structural Static Test*: Either the complete existing structure or major components of it are loaded in a testing machine or by dead weights or by hydraulic jacks or other well known means. Strain measurements are made in two principal ways:

(a) By cementing bonded-wire resistance strain gages, or any others that will do the job, all over the structure and watching the development of the stress pattern while loading by increments. The recording is done by motor-driven self-balancing bridge, marking by pen and ink on a large chart either strain values only or, as will be possible at some future date, the desired terms of strain against applied load.

(b) By spraying the structure or component with a brittle lacquer which will crack at some reasonably low load. The cracks will appear at right angles to the lines of stress, and the intensity of the crack pattern will indicate clearly the stress level. To determine the high points of the stress pattern, cement wire strain gages to the points of most intense cracking. This method makes it possible to use less numbers of gages to get the same answer, but the brittle lacquer must be used under controlled conditions. From the static test data, engineers make a judicious redistribution of material, mass and stiffness to iron out high spots, strengthen weak points, and get rid of any parts which don't contribute their proper share.

III. *The Dynamic or Life Test*: Structural fatigue-testing machines are the third tool for engineering testing developed in this new era of measured structures. The principal types are those with mechanical oscillators for inducing alternating forces that are constant throughout the test; electronic drives or electromagnetic motors which work like huge loud speakers; rotating-beam types which also apply constant loads; mechanical machines that work from rotating cams, cranks, or eccentrics; hydraulic types in which a reversing double-acting piston responds to the rapid push-pull of little pumps.

The interesting thing about life testing of parts and components is that the one test simultaneously tests the material, the joint, the surface condition, the influence of stress levels and notch sensitivity one upon the other, picks out stress-raisers and is thus a test of both the design and the workmanship, because nothing else shows these points up so quickly. If the failures do not reproduce service failures then restraints and modes of loading must be altered until reproduction is achieved.

IV. *Engineering Interpretation*: This is the big part. How will the data influence the design? This is where the engineer, the metallurgist and the stylist should get together. If they don't, each one has hurt the other. At this stage of the game, filing of data because there is too much of it or because time is too short to use it is the same thing as making a bonfire of dollar bills.

V. *Wind-Tunnel Tests and High-Speed Motion Pictures*: For things that move, and where equipment is available, these are important steps for obvious reasons. Though essential for aircraft, for automotive and rail equipment they add the finishing touches to a thorough job. The high-speed motion picture method of analyzing motions for improvement is easy and effective.

VI. *The Performance or Service Test*: This is to prove the pudding. In aircraft it is called flight testing, with telemetering apparatus where strains, accelerations and other data are radioed to the ground, and includes landing and dive tests, and flutter and vibration studies. In automotive equipment it is the work done on the proving ground with adequate instrumentation. — *From a paper by Francis G. Tatnall, The Baldwin Locomotive Works, presented at the recent annual meeting of SAE in Detroit.*

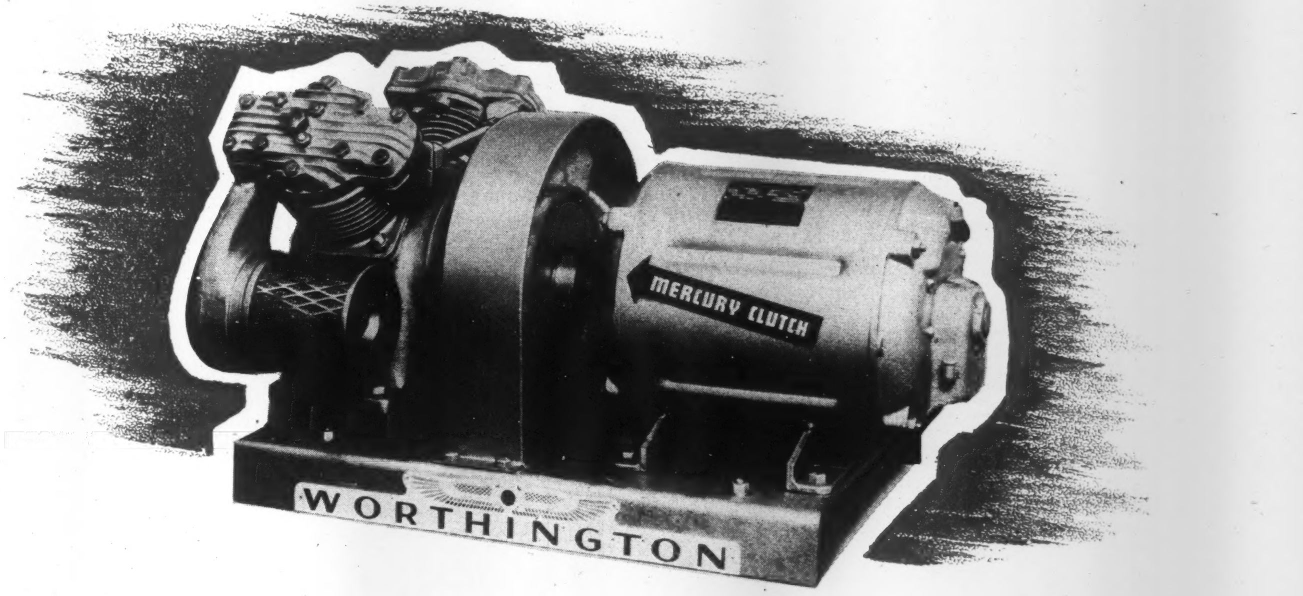
Quick-Change Horsepower

AIRCRAFT motive horsepower can be had in such neat packages that it seems a simple trick to unplug a worn-out package and plug in a fresh bundle of power —like changing a worn-out electric light bulb. When Lockheed demonstrated a Constellation power unit that could be detached from an airplane and put back in twenty-seven minutes, there was no lack of interest. Maintenance men began to toy with idyllic dreams of changing engines in less time than is required to change a set of spark plugs.

Into four "eggs", each just a little over six feet long and five feet in diameter, comprising the forward portions of the engine nacelles, have been crammed nearly everything the airplane needs in the way of power—to move its landing gear and control surfaces, generate its electricity, operate its instruments, and move it through the air at five miles a minute. Unscrew seventeen hoses and tubes, disconnect three electrical combination plugs, and seven electrical leads, remove four control linkages, pull out ten short bolts, and a power egg comes off the airplane as a complete unit. The twenty-seven minute record was made by a trained Lockheed crew who dismounted and reinstalled one of the power eggs on a Model 49 Constellation. This sounds like up-to-the-minute Design Thinking. Maximum utilization of the plug-in feature is then a matter of proper Planning.—*From a paper by R. W. Lahners, Trans World Airlines Inc., presented at the recent annual meeting of SAE in Detroit.*

MERCURY "AUTOMATIC TORQUE CONTROL"

is a Feature of the New Worthington Air King Compressor

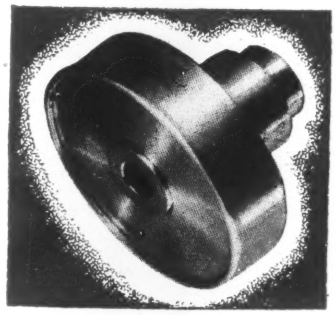


Motor Attains Full Speed Before Compressor Turns

The motor on the new Worthington Air King Compressor is off to a good start before the compressor itself turns over . . . before the compressor load is applied. Mercury Automatic Torque Control, installed between the motor and the compressor, provides a simple and satisfactory solution to the starting problem. Troublesome bleeder valves, air releases and other unloading gadgets are eliminated. If you design Aircraft or Stokers . . . Blowers or Pumps . . . Conveyors or Power Saws . . . Electrical Appliances or Packing Machinery . . . anything requiring an electric motor or internal combustion engine . . . investigate Mercury Automatic Torque Control. Its application to your design results in all or most of these improvements: (1) Reduced starting current. (2) A better power factor. (3) A lower connected load. (4) Overload protection. (5) Use of a smaller motor under some conditions.

Wherever there's a motor in your plant . . .

you can make starting easier and eliminate high current drain by installing Mercury Automatic Torque Control. Submit your problem.



What is Mercury Automatic Torque Control?

It consists of an automatic mercury-actuated clutch installed between the motor and its load. It includes a driving member carried direct on the motor shaft and a driven member connected to the load by a pulley and V-belt or a direct coupling. In operation, the inertia delay of the actuated mercury retards the engagement of the friction members of the clutch for a second or so or long enough for the motor to reach full speed before it picks up the load. The motor is able to bring to bear its greatest torque in starting the load, accelerating it gently and uniformly. *Write for your copy of Mercury Catalog MD-4.*

MERCURY CLUTCH CORPORATION
1504 - 12th Street, S. W., Canton, Ohio.
New York Office: 19 Rector Street.

MERCURY *Clutch* **AUTOMATIC TORQUE CONTROL**

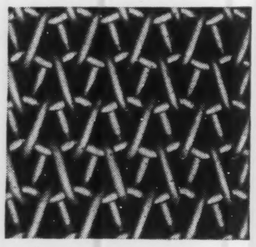
Cambridge

BALANCED BELTING

Guards product cleanliness In processing and handling

Typical of the efficiency of Cambridge Balanced Belting is this use in conveying packaged cement. The sturdy open mesh permits loose cement to sift through the belt, keeping the bag clean during handling. For efficient, dependable service in handling or processing your products—at reduced costs—it pays you to use Cambridge Balanced Belts.

For the practical, economical solution to your conveying problems—write Cambridge today, Dept. 21.



Close-up showing alternate spiral construction and crimped wire connection of Cambridge Balanced Mesh Belt.

Cambridge
CONVEYOR
BELTS

FREE....

Valuable, illustrated catalog. Complete, practical reference for all belt users. Write Dept. 21 for your copy.

CAMBRIDGE WIRE CLOTH CO.
CAMBRIDGE, MARYLAND

Boston • New York • Baltimore • Pittsburgh
Detroit • Chicago • St. Louis

BUSINESS AND SALES BRIEFS

TEN men have been added to the sales staff of The Allegheny Ludlum Steel Corp., Pittsburgh. They are: Joseph B. Parsons, Sidney M. McCroskey, Edward J. Stein, Wallace H. Adamson, George D. Bunder, Harold M. McMeans, William G. Memphill, Robert A. Wille, Edward W. Schnabel and George A. Estabrook.

◆

General sales manager since 1938, Carl H. Beck has been elected vice president of Westinghouse Air Brake Co. He will assist in research and the development and exploitation of new equipment.

◆

Metal Goods Corp. has been appointed by The Standard Tube Co. of Detroit to serve as sales representative and distributor in the states of Arkansas, Colorado, Kansas, Louisiana, Missouri, Nebraska, Oklahoma, Tennessee and Texas. The newly appointed company maintains sales offices and warehouses in St. Louis (headquarters) and Kansas City, Mo.; Houston and Dallas, Tex.; Tulsa, Okla.; and New Orleans, La.

◆

A new branch will be opened in Los Angeles by Pennsylvania Flexible Metallic Tubing Co. It will be under the supervision of Arnold J. Dovey, and will be known as the Pacific Coast division of Penflex Sales Co., a sales organization of the Pennsylvania Flexible company. The branch will cover the territory from the Mexican to the Canadian borders, and as far east as Salt Lake City.

◆

Roland E. Nelson has succeeded George L. Green as manager of the Chicago office of H. K. Porter Co. Inc., Pittsburgh 22. For the past year Mr. Nelson served as sales engineer in the St. Louis territory.

◆

Formerly in the Detroit office, Rex Wilson has been transferred to the Pittsburgh office of The Monarch Machine Tool Co. He will report to district manager E. L. Ross. N. L. Dilworth, who has been in the home office at Sidney, O., will become a field sales engineer for the company, with headquarters in Toledo, O. Mr. Dilworth will report to Hugh W. Robinson, Cleveland district manager.

◆

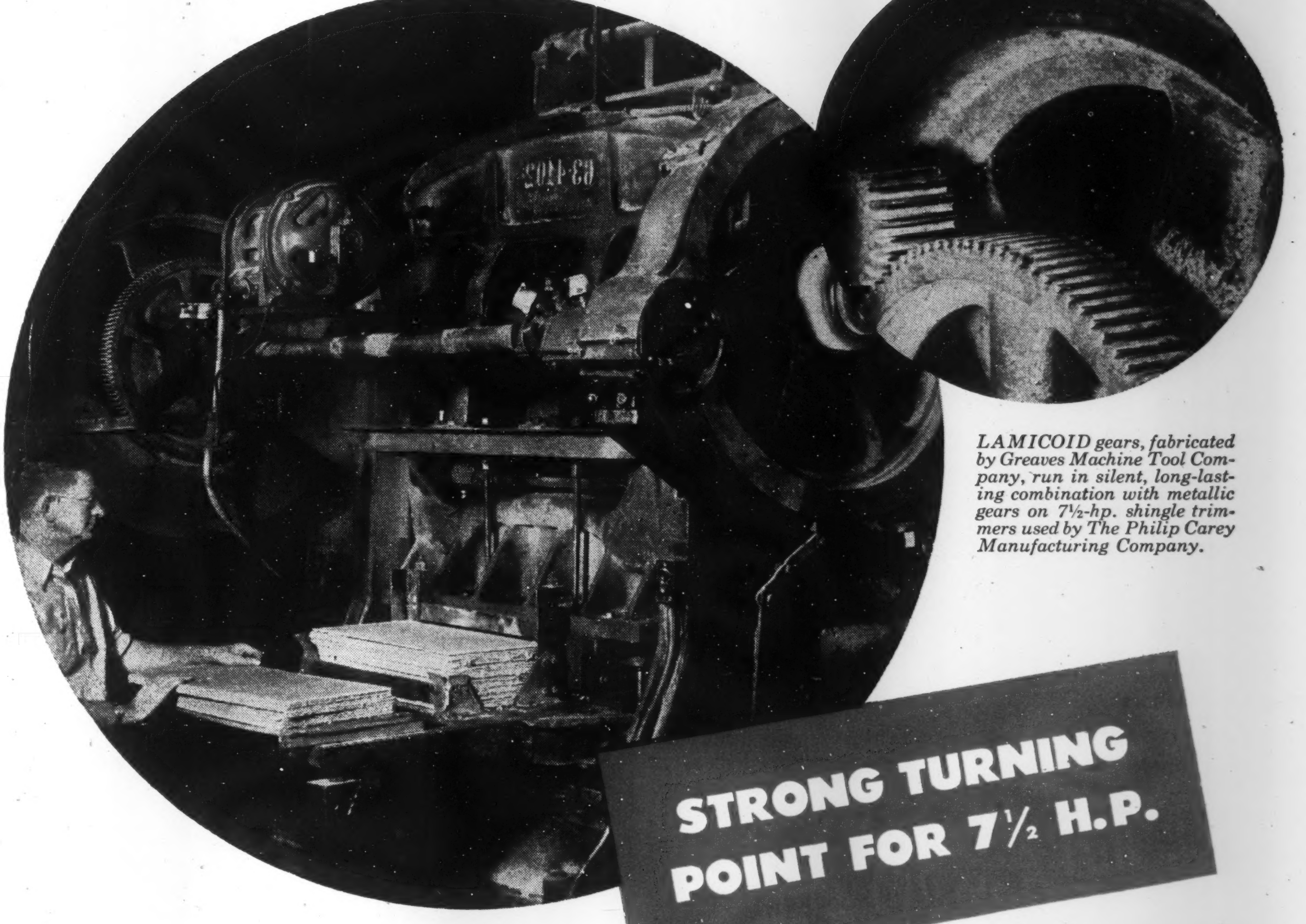
Change of name to Ladish Co. has been announced by Ladish Drop Forge Co., Cudahy, Wis. The new name better reflects the expanded scope of the company's activities.

◆

American Brake Shoe Co. has named Stephen S. Conway as vice president and Ralph L. Robinson as assistant vice president in the sales department of the Brake Shoe & Castings Division. Prior to his appointment Mr. Conway was assistant vice president in sales, while Mr. Robinson was district sales manager.

◆

Recent changes in territory personnel and the addition of a new district have been announced by Telechron Inc. Harold D. Stanton, previously district manager of the middle western district with headquarters in St. Louis, has been transferred to the



LAMICOID gears, fabricated by Greaves Machine Tool Company, run in silent, long-lasting combination with metallic gears on 7½-hp. shingle trimmers used by The Philip Carey Manufacturing Company.

STRONG TURNING POINT FOR 7½ H.P.

LAMICOID gears, large or small, built into the most simple or complex machines help provide better power transmission when run in combination with steel or cast iron. They are ideally suited for applications where high impact strength and quiet operation are of prime importance. In fact, in many instances their performance is superior to that of metallic gears.

But there are other features, too, that appeal to material and production-minded gear designers. One is the fine working properties of this thermosetting laminated plastic. Capable of being blanked or machined to remarkably close tolerances, it permits higher operating feeds and increased cutting speeds. Should small errors in tooth form or spacing occur, they are readily absorbed by the "muscle" in LAMICOID—with little effect on strength and performance.

Other important features of LAMICOID include its ability to absorb abrasive dusts . . . its resistance to corrosion, moisture and dilute acids . . . and its self-lubricating characteristics.

For full details about LAMICOID — consult our nearest sales office or fabricator about *your* gear requirements.

MICA INSULATOR COMPANY

Dept. 20, Schenectady 1, N. Y.

SALES OFFICES: Boston • Chicago • Cincinnati • Cleveland Detroit • New York • St. Louis • Philadelphia • Rochester Western Fiberglas, Ltd., San Francisco and Los Angeles, Calif.

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Gentlemen:
Please send me a free copy of your new 16-page manual, "How To Make Gears With LAMICOID".

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HOW TO TIGHTEN A SOCKET SCREW'S GRIP
. . . without safety wires

Specify BRISTO "Multiple-Spline"

Defying vibration that often shakes "hex" screws loose . . . speeding assembly of products with hard-to-reach fastening points . . . easing disassembly — BRISTO "Multiple-Spline" Socket Screws are now making a hit with many designers and production men.

BRISTO "Multiple-Spline" gets its tighter grip from the unique way the wrench, geared to the spline-shaped socket, pulls the screw around. No expanding pressure. No bursting or rounding out of socket walls. Yet, a flick of the wrench releases the deep-seated grip.

Literature describing BRISTO "Multiple-Spline" Socket Screws and their many applications is yours for the asking.

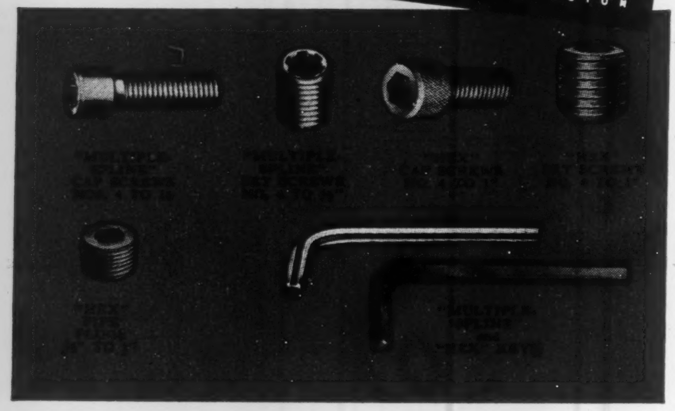
THE BRISTOL COMPANY, Mill Supply Division,
122 Bristol Rd., Waterbury 91, Conn.

WHY "MULTIPLE-SPLINE" MEANS TIGHTER
NO EXPANDING PRESSURE: THE KEY PULLS THE SCREW AROUND

MULTIPLE SPLINE SOCKET
BRISTO SET & CAP SCREWS

Only the "B-LINE" has the right socket screw for every application

The BRISTOL Company
MILL SUPPLY DIVISION



central district which consists of the states of Ohio, Michigan and western Indiana, with headquarters in Cleveland. John F. Tigue, formerly a salesman in the Cleveland territory, has been promoted to district manager in charge of the large middle western district covering Missouri, Arkansas, Kansas, Nebraska, Iowa and parts of Wisconsin, Illinois and Indiana. Richard D. Tyler, previously a salesman working out of the Chicago office, has been named district manager of a newly established district which includes western New York, western Pennsylvania, West Virginia and Kentucky, with headquarters in Pittsburgh.

◆

With headquarters at 185 Devonshire St., Boston 10, W. C. Straub has been appointed sales representative in the New England territory of The Monitor Controller Co., Baltimore, Md.

◆

James E. Fitzgerald and Harvey E. Zens Jr. have joined the sales organization of Udylite Corp. and are assigned to the Detroit office. Formerly Mr. Fitzgerald was associated with Plymouth Motor Car Co., Nicolay Dancey and Howe Martz Glass Co. Mr. Zens was connected with Dodge Motor Co., Carboloy Co. and Meier Brass & Copper Co.

◆

According to a recent announcement, Dale L. Bennett has been named Mid-Western zone manager of Briggs Filtration Co., Bethesda 14, Md. Mr. Bennett will make his headquarters in Chicago.

◆

Southern Sales Co., 1135 Lincoln Tower, Fort Wayne 2, Ind., has been appointed by Ward Leonard Electric Co. to serve as industrial representative in Indiana and western Kentucky. The newly appointed company will also continue to represent Ward Leonard in the Electronic Distributor Division.

◆

Formerly general sales manager, Vincent Manka has been elected vice president of Claud S. Gordon Co., Chicago, specialists in the heat-treating and temperature control field.

◆

To succeed Fred D. Ranyard who retired recently, The B. F. Goodrich Co. has appointed Paul R. Wineman as manager of the Seattle district of the Industrial Products Sales division. For the last five years Mr. Wineman has been a salesman in the Los Angeles district.

◆

Change of name has been announced by Dardelet Thread-Lock Corp., Detroit 11. Henceforth the company will be known as Lock Thread Corp.

◆

Carboloy Co. Inc., Detroit, has appointed the Kendall Hardware-Mill Supply Co., 225 West Michigan Ave., Battle Creek, Mich., to serve as an authorized distributor in the Battle Creek and Kalamazoo areas of southwestern Michigan. Headquarters office and salesroom will be maintained in Battle Creek, with a branch office in Kalamazoo. C. B. Cramer is general manager of the Kendall company.

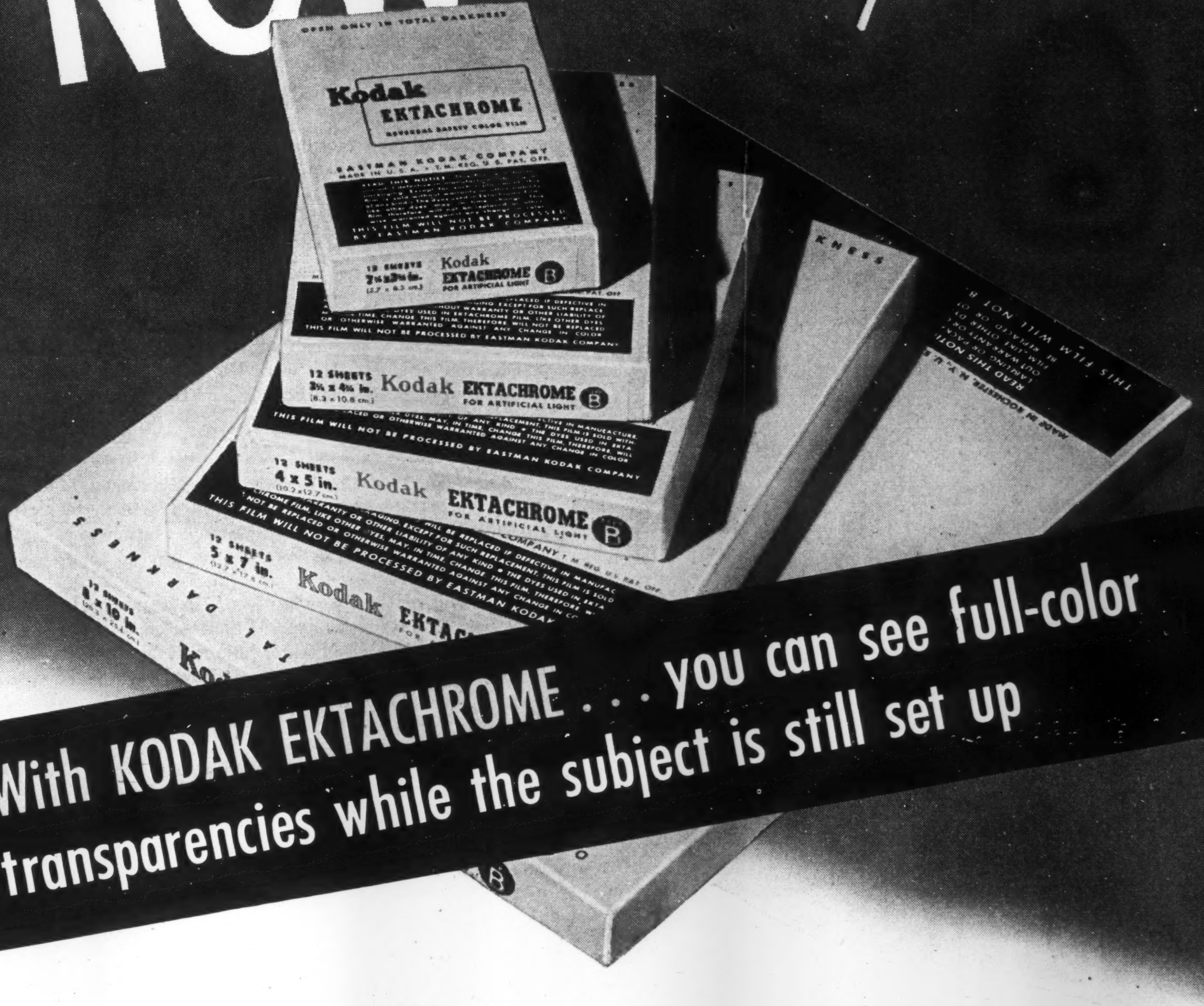
◆

According to a recent announcement, Herbert V. Evans Jr. and H. C. Grieme have joined the sales department of Alloy Steel Products Co., Linden, N. J.

◆

Formerly manager of industrial sales department of Westinghouse Electric Corp., C. B. Stainback has been appointed industrial syndicate manager. This is a new position created to better co-ordinate the industrial sales activities of the company. John E. Payne, previously manager of industrial sales for the central district, has succeeded Mr. Stainback as

NOW ... color film you can process yourself


Kodak
EKTACHROME
12 SHEETS
Kodak EKTACHROME
FOR ARTIFICIAL LIGHT
4 x 5 in.
5 x 7 in.
8 x 10 in.
THIS FILM WILL NOT BE PROCESSED BY EASTMAN KODAK COMPANY

With KODAK EKTACHROME . . . you can see full-color transparencies while the subject is still set up

When you want to judge results of color photography without delay, in your own darkroom . . . that's the time you appreciate Kodak Ektachrome!

With it, you have quick, convincing proof that you've accurately pictured the fine color differences that tell significant stories in industrial research and control. For instance . . .

If you're a metallurgist, Ektachrome enables you to picture quickly, and study at leisure, colors brought out by etchants and polarized light—colors that identify inclusions, segregate phases, oxidation and diffusion zones.

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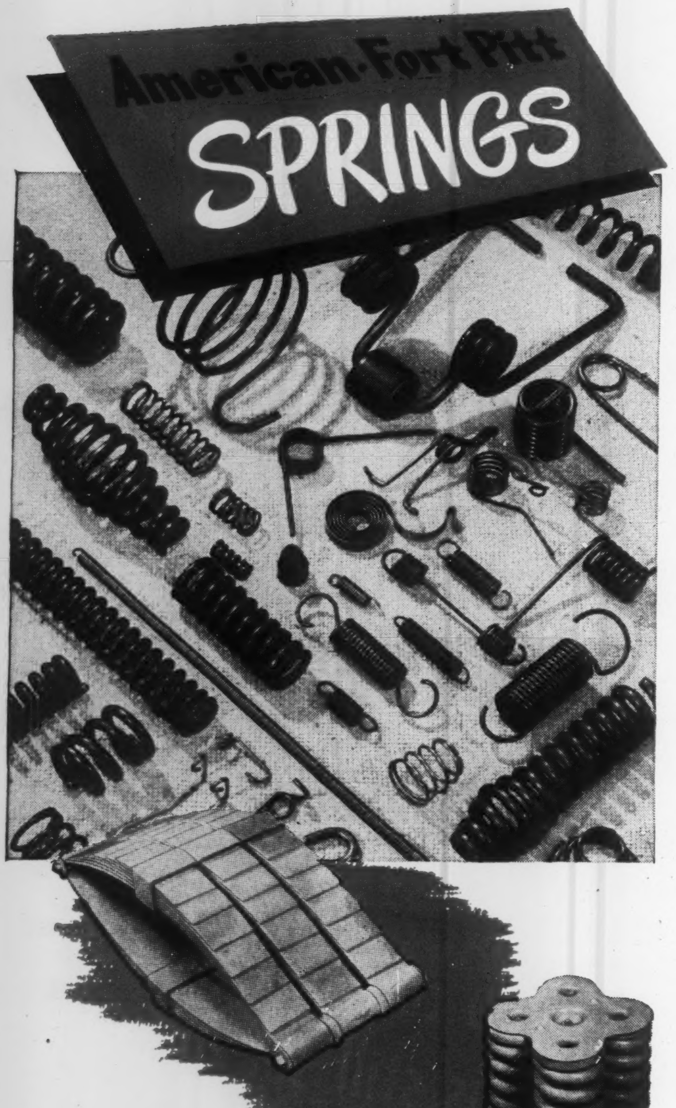
* * *

Ask your Kodak dealer for Ektachrome. He has this quick-processing color film in all the standard sheet film sizes . . . together with complete instructions and processing chemicals that are just as safe as ordinary developers.

EASTMAN KODAK COMPANY
Rochester 4, N.Y.

Kodak



AMERICAN-FORT PITT SPRING DIVISION
PORTER
"Better Built"
EQUIPMENT

The merger of American Spiral Spring & Mfg. Co., and Fort Pitt Spring Co. has brought together two of the oldest spring manufacturers to form one of the *largest* spring producers in the country. This combined equipment and experience offers exceptionally complete facilities for the manufacture of all types of springs, from heavy coil and elliptic springs for cars and locomotives, to the smallest helical wire and flat springs for all purposes. Our engineering facilities are at your disposal to help solve your intricate spring problems.

PORTER-BUILT *means* BETTER-BUILT

American-Fort Pitt Spring Division
H. K. PORTER COMPANY, Inc.
PITTSBURGH 22, PENNSYLVANIA
District Offices in Principal Cities

headquarters industrial sales manager. Also announced by Westinghouse are plans to expand manufacturing facilities at the Buffalo plant. The new operation, formerly a part of the Switchgear and Control Division at East Pittsburgh, will be known as the Industrial Control Division. L. R. Ludwig, manager of the Motor Division, has been assigned responsibility for this operation. Eventually operations at Buffalo will include motor industrial control, copper wire and welding activities, and will be known as the Buffalo Divisions, rather than the Buffalo Motor Division.

◆

P. F. Bronckhurst, western representative for Hydropress Inc., will move his office permanently from Denver, Colo., to San Francisco.

◆

According to a recent announcement by Taylor Instrument Cos., Robert E. Paxson has been established in the Midwest with headquarters in St. Louis. He is the newest member of the sales force.

◆

Having completed sixty-one years of continuous service, "Reg" B. Calcutt retired recently from active duty in United States Rubber Co. He is well known in the middlewest where he served as a salesman of rubber belting, hose and other industrial products. His work has been turned over to L. W. Moore and F. B. Harrison Jr., in the branch office at 440 West Washington St., Chicago.

◆

Michigan Tool Co. has appointed Anderson Machine Tool Co., 2641 University Ave., St. Paul 4, Minn., to serve as its exclusive representative in the state of Minnesota.

◆

Election of the following has been announced by Appleton Electric Co., Chicago, manufacturer of conduit fittings, electric extension reels, air and water hose reels and auto driving lights: Arthur I. Appleton, president; Albert I. Appleton, chairman; and John A. Appleton, vice president.

◆

A new office has been opened at 528 White Bldg., Buffalo, by Kennametal Inc., Latrobe, Pa. Harry W. Bearfoot has been transferred from Pittsburgh to the new office where he will serve as tool engineer and representative.

◆

Cleveland Chain & Mfg. Co., Cleveland, has announced the purchase of Woodhouse Chain Works, Trenton, N. J. The Trenton plant will continue in full operation as the Woodhouse Chain Works Division of the company. E. S. Washburn will remain in charge as plant manager.

◆

With headquarters at 445 Lake Shore Drive, Chicago, George W. Marshall Jr., has been appointed general sales manager of the Asbestos Products Division of Raybestos-Manhattan Inc. He will continue to serve as general manager of the Asbestos Textile and Packing Division and in addition will direct the sales activities of the company's Equipment Sales Division.

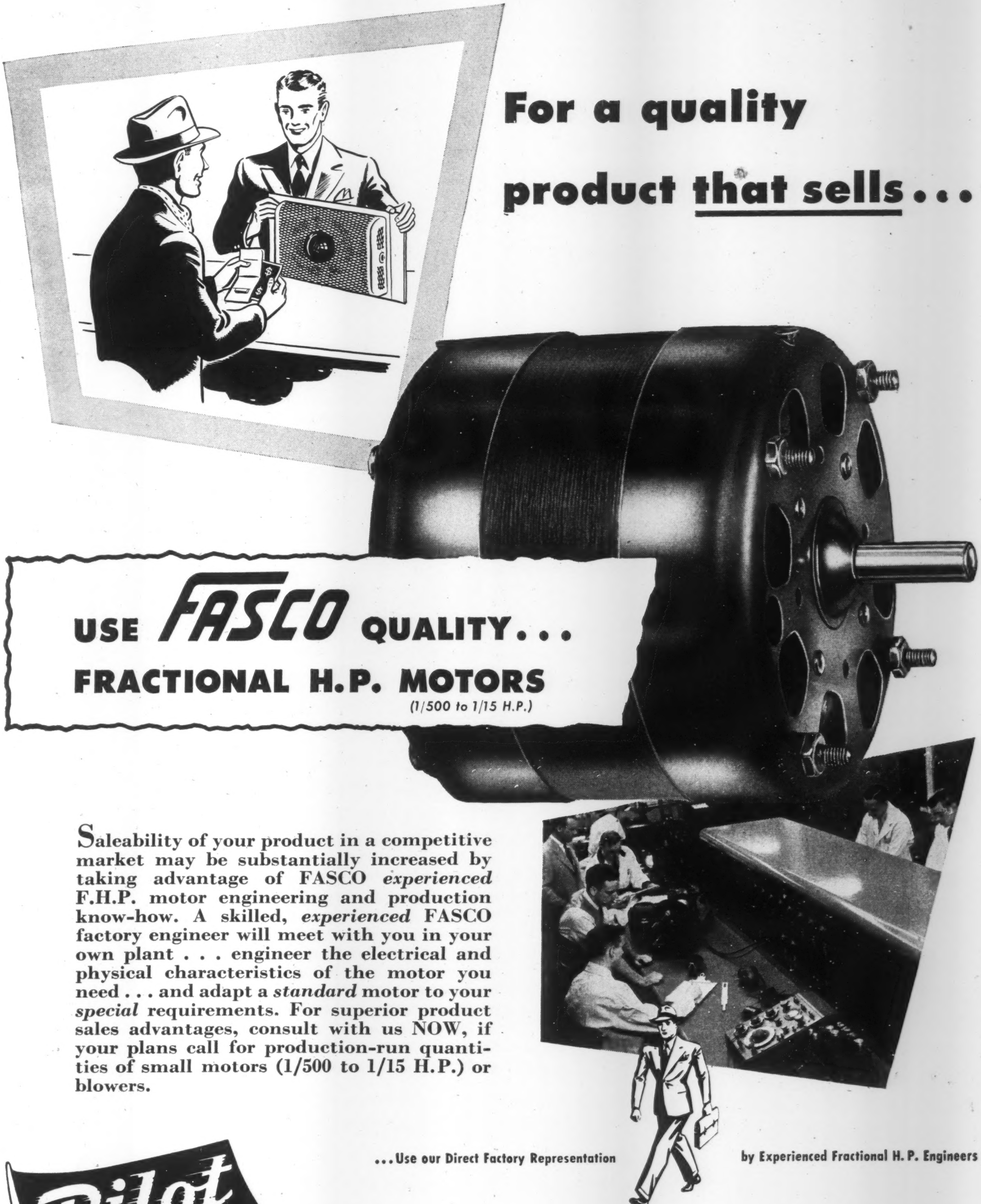
◆

Offices have been opened at 1 Wall St., New York, by Leo H. Rich Inc., industrial consultants.

◆

Recently announced is the election of L. M. Morley as a vice president of Minneapolis-Honeywell Regulator Co. He will continue to serve as vice president in charge of sales for the Brown Instrument Co., a wholly-owned subsidiary at Philadelphia.

For a quality product that sells...



USE FASCO QUALITY...
FRACTIONAL H.P. MOTORS
(1/500 to 1/15 H.P.)

Saleability of your product in a competitive market may be substantially increased by taking advantage of FASCO *experienced* F.H.P. motor engineering and production know-how. A skilled, *experienced* FASCO factory engineer will meet with you in your own plant . . . engineer the electrical and physical characteristics of the motor you need . . . and adapt a *standard* motor to your *special* requirements. For superior product sales advantages, consult with us NOW, if your plans call for production-run quantities of small motors (1/500 to 1/15 H.P.) or blowers.

...Use our Direct Factory Representation by Experienced Fractional H. P. Engineers

Pilot
Fractional H.P.
MOTORS & BLOWERS

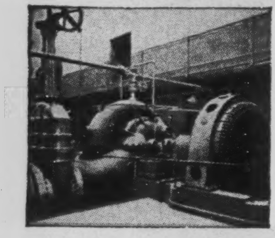
A PRODUCT OF **FASCO**

F. A. SMITH MANUFACTURING CO., INC.
550 Davis St., Rochester 2, N.Y.

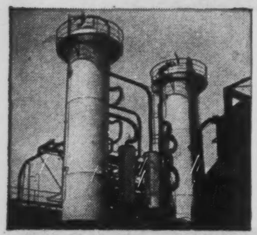
INDUSTRY BANS RUST AND CORROSION *with* EVERLASTING FASTENINGS

Few industries can escape the destructive effects of rust and corrosion but *all* industries can reduce their costly ravages in maintenance and breakdown.
Here are five industrial applications where Harper's EVERLASTING FASTENINGS have licked rust and corrosion.

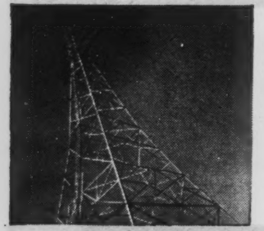
MONEL STOPS CORROSIVE CHEMICALS Problems in salt production have been solved by using Monel bolts. In mining, treating and handling of many chemicals, nonferrous alloys are the answer to efficient operation.



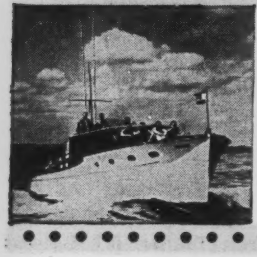
BRASS GUARDS WATER SYSTEMS In valves and pumps that compose the heart of water works, Brass fastenings help in eliminating the most common cause of replacement—rust.



STAINLESS STEEL SOLVES OIL PROBLEMS Acids and gases at high temperatures attack metal but Stainless Steel alloys cut refinery replacements to a minimum, assure years of continued operation.



UTILITIES CHOOSE SILICON BRONZE Weather is the bug-a-boo in power lines and other utility applications. Silicon Bronze Bolts reduce season "cracking" and maintenance costs.



NAVAL BRONZE WINS ON THE SEA Marine applications demand high strength plus resistance to salt air and water. Naval Bronze fastenings have proved their dependability in marine diesels and ship fittings.

THE H. M. HARPER COMPANY 2626 Fletcher Street
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Call upon Harper to solve fastening problems in *your* industry

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Everlasting Fastenings
Chicago

MEETINGS AND EXPOSITIONS

April 16-18—
Society of Automotive Engineers Inc. Transportation meeting to be held at Stevens Hotel, Chicago. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

April 28-May 1—
American Foundrymen's Association. Fifty-first annual convention to be held in Detroit. Convention headquarters will be shared by the Statler and Book-Cadillac Hotels. William W. Maloney, 222 West Adams St., Chicago 6, is secretary of the association.

May 6-10—
Second National Plastics Exposition to be held in conjunction with the annual meeting of the Society of the Plastics Industry. Conference headquarters will be at Stevens Hotel, Chicago, and exposition will be at Chicago Coliseum. William T. Cruse, 295 Madison Ave., New York 17, is executive vice president of the society.

May 15-17—
Society for Experimental Stress Analysis. Annual meeting including a symposium on shock and impact to be held at Stevens Hotel, Chicago. Additional information may be obtained from the society at P. O. Box 168, Cambridge 39, Mass. W. M. Murray is secretary-treasurer.

May 21-24—
American Society of Mechanical Engineers. Oil and gas power nineteenth national conference to be held at Cleveland. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

May 22-31—
Mid-America Exposition to be held at Public Auditorium, Cleveland. Parker Hill, vice president of the Cleveland Chamber of Commerce, is secretary.

May 26-29—
American Society of Mechanical Engineers. Aviation meeting to be held at Los Angeles. Additional information may be obtained from headquarters of the society at 29 West 39th St., New York. C. E. Davies is secretary.

June 1-6—
Society of Automotive Engineers Inc. Summer semiannual meeting to be held at French Lick Springs Hotel, French Lick, Ind. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

June 2-4—
American Gear Manufacturers Association. Thirty-first annual meeting to be held at The Homestead, Hot Springs, Va. Newbold C. Goin, Empire Bldg., Pittsburgh 22, is executive secretary.

June 2-4—
American Society of Heating and Ventilating Engineers. Semiannual meeting to be held at Hotel del Coronado, Coronado, Calif. A. V. Hutchinson, 51 Madison Ave., New York 10, is secretary.

June 16-19—
American Society of Mechanical Engineers. Semiannual meeting to be held at Stevens Hotel, Chicago. C. E. Davies, 29 West 39th St., New York, is secretary.

June 16-20—
American Society for Testing Materials. Fiftieth annual meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. R. J. Painter, 1916 Race St., Philadelphia 3, is assistant to the secretary.

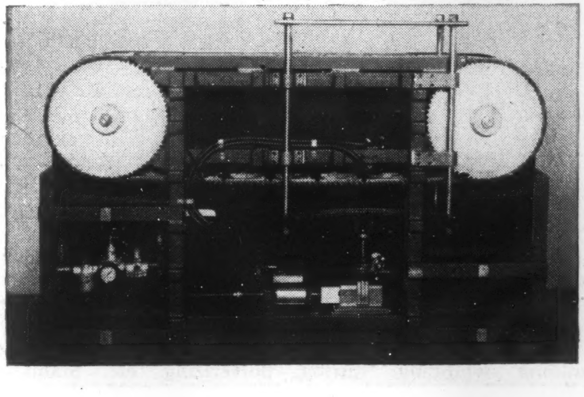
June 23-27—
American Electroplaters' Society. National convention to be held in conjunction with Industrial Finishing Exposition. Convention headquarters will be at Hotel Statler, Detroit, and exposition will be at Convention Hall. Additional information may be obtained from headquarters of the society at 93 Oak Grove Ave., Springfield, Mass.

Wichita City Library

NEW Automatic MACHINE

TESTS Condenser COILS

Trap doors spring open at any one of four testing stations on this conveyor-type automatic testing machine, sorting and rejecting defective coils in an uninterrupted operation.



Barth-designed coil testing machine built to save manhours and up production

HOW TO test condenser coils for electrical flaws . . . automatically reject faulty coils at high speed . . . was the problem put to Barth engineers. The difficulty was acute, for the operation had to be continuous and accurate in detecting (1) over potential, (2) under potential, (3) grounded, and (4) capacity variance in the condensers.

BARTH ENGINEERS found the answer in the machine pictured above, designed and built by Barth for a large electrical manufacturer. Entirely automatic, this air-operated machine tests the coils, drops out rejects, passes perfect units in a steady flow . . . ups production sharply.

PERHAPS this example suggests an undiscovered solution for *your* production problems. Our experience is at your service. You will find it a diversified service . . . on design and manufacture of dies, tools, gauges, jigs and *special machinery* . . . with skilled engineers ready to help you find whatever type and kind of service is best for your applications.

BARTH STAMPING & MACHINE WORKS Inc.
Denison at W. 34th St., Cleveland 9, Ohio

DESIGNERS AND BUILDERS OF DIES, TOOLS AND SPECIAL MACHINERY

the light that must not fail
and vital equipment parts . . .

BOTH RELY ON FELT FOR UNFAILING OIL FLOW

American felt plays an important role in railroading.

The kerosene lamp for switch and signal lights must not fail—so *felt* wicks are used to feed oil constantly to the precious flame. Similarly, the journal bearing . . . which helps railroad cars ride more smoothly . . . receives constant lubrication from a *felt* wick.

Felt is the solution to these and many more difficult lubrication jobs . . . because *only* felt will hold oil ready to bleed at the friction point. Whether the flow is up or down, for long or short distances, felt stores the lubricant, always ready when and where needed.

You will find felt wicks the preferred agent for lubricating large and small motor armature shafts, spindles and other remote machine parts. Felt pads absorb, store and distribute oil, water, ink and other process fluids in automatic printing equipment, cash registers and postage meters. For complete details please write on your letterhead, requesting Data Sheet #6 "Wicks and Lubrication."

American Felt Company
TRADE MARK

General Offices: Glenville, Connecticut

PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.
SALES OFFICES: New York, Boston, Philadelphia, Atlanta, Rochester, Chicago, Detroit, Cleveland, St. Louis, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.

NEW MACHINES

And the Companies Behind Them

Air Conditioning

Portable electric window ventilator. Exhaust-type. Supplies twelve complete air changes hourly for average size room. Fits window widths of 22 to 27, 24 to 31 and 27 to 36 inches. Metal-Tex. Corp., Racine, Wis.

Combination heater-cooler fan. Designed with deflector to provide maximum effective distribution of air. Height and diameter, 10 inches. Howard Industries, Chicago.

Window model room coolers, portable room coolers, and packaged air conditioning units for stores, large offices and hotels. Kauffman Air Conditioning Corp., St. Louis.

Automotive

Lightweight scooter. Weighs only 75 lb. Has 4-hp gasoline engine. Will fit into average automobile trunk. McCulloch Motors Corp., Los Angeles 45.

Business

Audio amplifiers for public address systems. Included are 8, 25 and 50-watt amplifiers, a preamplifier and a booster. Thordarson Electric Mfg. Div., Maguire Industries Inc., Chicago.

Coin-operated radio for use in hotel rooms and similar locations. Set is a two-band receiver, with six tubes, and a built-in loop antenna. Radio Corp. of America, Camden, N. J.

Combination recorder, record player and public address system. Dual speed permits recording at 33 1/3 rpm or at 78 rpm. Bell Sound Systems, Columbus, O.

Chemical

Hammer mill with overall height of 47 in., a base 53 x 38 in. and a charge opening of 24 x 30 in. Use for grinding, pulverizing, crushing, shredding and defiberizing various materials. Buffalo Hammermill Corp., Buffalo 3.

Thermostatically controlled melting tanks, indirectly heated, fully-insulated, for heating, melting, dipping and pouring critical compounds. Aeroil Products Co., West New York, N. J.

Cleaning

Screw-drum washer and dryer for washing, rinsing and drying. Can also be adapted for a wash-drain, rinse-drain, cold or hot-air dry sequence, or for pickling operations. Optimus Equipment Co., Matawan, N. J.

Domestic

Electric food mixer with large mixing bowl off center from beater. Control dial requires one setting for each food operation. Westinghouse Electric Corp., Pittsburgh.

Electric iron. Weighs 4 oz and is equipped with 3-way plug for three heats, replacing thermostats. Haines Mfg. Corp., Chicago.

Electric barbecue. Automatic. Revolves meat eight times per minute. Appliance Industries of America, Chicago.

Single cocktail mixers. Mix in 3 to 10 seconds. Various models available. Have strainer tops of stainless steel, and blunt agitators. Motor runs one 110 volts ac or dc. Other voltages available. John Oster Mfg. Co., Racine, Wis.

Mixer for liquefying, beating, chopping, mixing, blending shredding, whipping, stirring, pulverizing, etc. Stainless blades whirl at 20,000 rpm delivering 80,000 chopping strokes per minute. John Oster Mfg. Co., Racine, Wis.

Mechanical massage instrument, delivering several thousand rotary patting Swedish massage type movements per minute. Motor operates on 110 volts ac or dc. John Oster Mfg. Co., Racine, Wis.

Personal radio, gold electroplated and catalin pocket-size type. Measures 6⅜ x 4⅝ x 4¼ in. Has built-in loop antenna and simplified battery replacement. Radio Corp. of America, Camden, N. J.

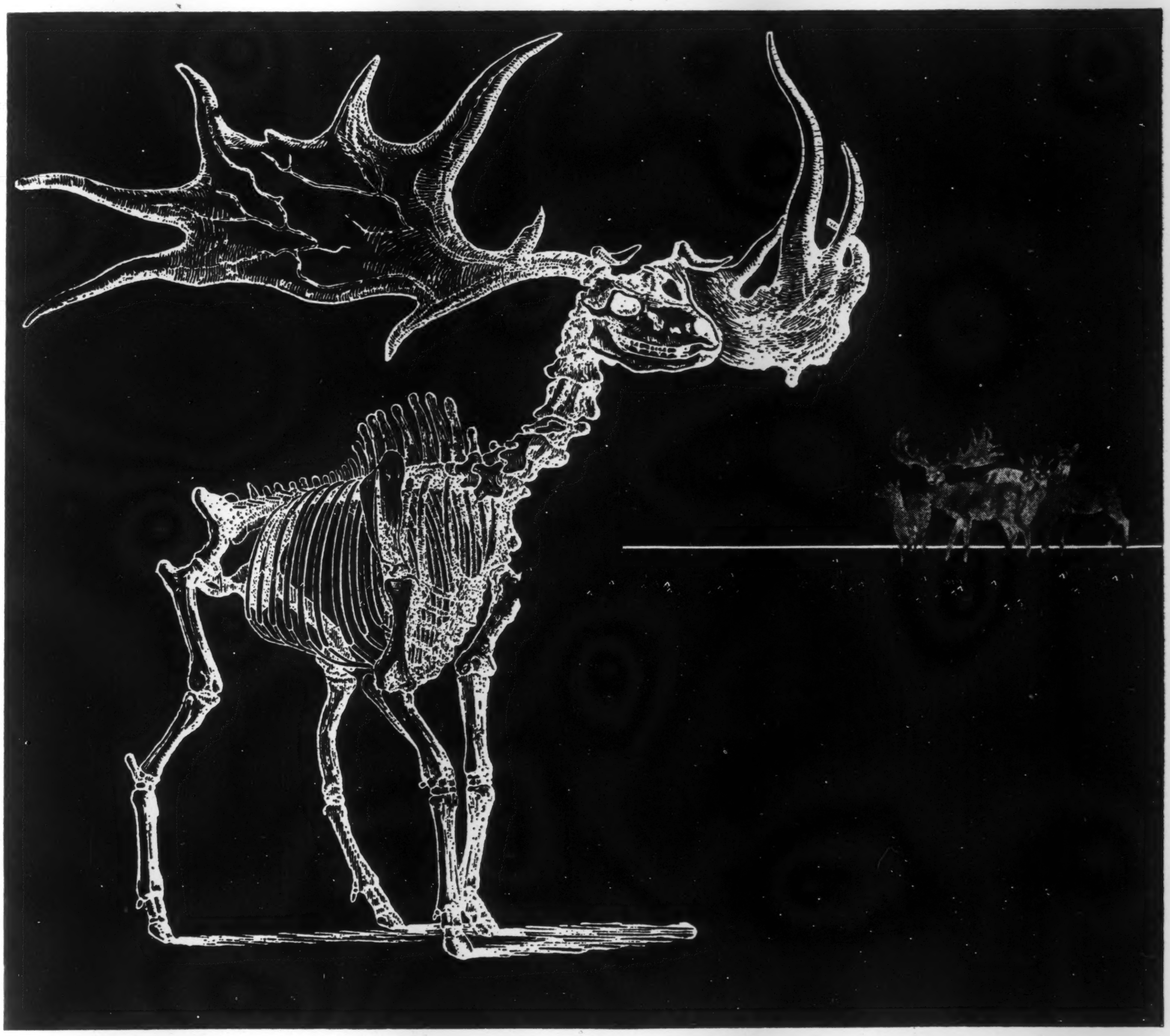
Table radio-phonograph, with concealed dial and controls, for ten intermixed 12 and 10-in. records, as well as ten 12-in.

THE ELK THAT ALSO RAN

Once upon a time an enormous elk with out-size antlers roamed the Irish forests. He was impressive but impractical; concentration of weight in the wrong place ruined his ability to meet competition.

The same thing can happen in modern machinery. Too much weight, especially in parts subject to rapid operation, can reduce efficiency considerably. The machine may not become extinct, but it won't make many friends.

There is a simple, economical way of avoiding such troubles—specifying molybdenum steels. Their hardenability permits weight reduction with no sacrifice in ability to meet service requirements. Practical data on request.



MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

MOLY

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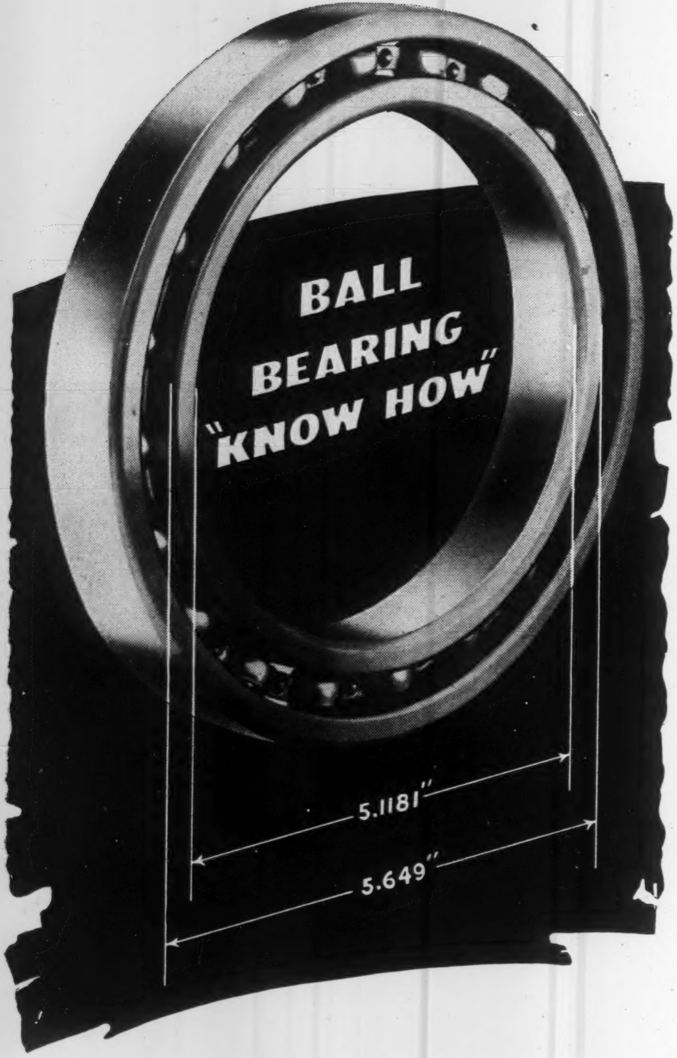


NOTE the exceptionally large diameter in relation to the race thickness of this radial ball bearing. It is not just an ordinary ball bearing—it's one that takes "ball bearing know how" to turn out to the exacting specifications of our customer. Tolerances allowed are close, for the piece of machinery into which this bearing goes is quality from end to end.

When you need "BALL BEARING KNOW HOW" *put it up to us.*

BEARINGS COMPANY OF AMERICA, LANCASTER, PA.

BCA RADIAL • ANGULAR CONTACT • THRUST BALL BEARINGS

or twelve 10-in. records. Automatically stops after last record. Crosley Division, Aviation Corp., Cincinnati.

Large deluxe gas and electric ranges. Have one-piece welded frames, one-piece top and waterfall front of acid-resisting porcelain. Equipped with signal timers. Crosley Division, Aviation Corp., Cincinnati.

Automatic ironer. Irons under roll which is suspended in a fixed position over a shoe. Can also press and steam. Bendix Home Appliances Inc., South Bend 24, Ind.

Dry Cleaning

Hat cleaning machine. Cools and cures hat crown and brim by vacuum. Speeds up finishing of hats over old method. Pantex Mfg. Corp., Pawtucket, R. I.

Extractor. Motor-driven. Equipped with interlocking safety cover and special vertical high-torque motor. Sizes: 20-26 and 30 in. Armstrong Machine Works Co. Three Rivers, Mich.

Glider press equipped with steam vacuum or air vacuum pump. Armstrong Machine Works Co., Three Rivers, Mich.

Finishing presser. Has wide head opening. Mushroom type. For dress finishing and pleating, E. L. Chrisman Co., Los Angeles.

Machine for washing and deodorizing garments. Will clean and deodorize 90 lb per hr, 30 lb per load. Has 36 x 18-in. stainless steel basket. Vic Cleaning Machine, Minneapolis.

Metalworking

Centerless wet-belt grinder. Adapted for ¾-in. to 2-ft lengths and longer. Diameters range from 3/32-in. to 2 1/4 in. Porter-Cable Machine Co., Syracuse, N. Y.

Two-way horizontal boring machine. Bores 12 in. deep from both sides of locomotive air cylinders. Individual drive provided for each head. Davis & Thompson Co., Milwaukee 14.

Indexing table for horizontal drilling and tapping machines, as well as for many other types of machines. Suitable for inspection or layout work also. Has 36-in. diam. indexing platen. Kaukauna Machine Corp., Kaukauna, Wis.

Automatic drilling machine built as standard tool for special purpose adaptations. Tooling heads mounted on machine saddle are removable. Saddle operated by hydraulic unit. Robbins Engineering Co., Detroit 3.

Printing machine for continuous or spaced impressions on tool steel, sheet steel or steel tube—all sizes of flat and round bars from ¼-in. square or ¼-in. diam. up, flats or sheets ¼-in. wide and up. Jas H. Matthews & Co. Pittsburgh 13.

Plastics

Injection molding machine for pieces up to 32 oz and projected area to 150 sq in. Normal mold locking pressure is 600 tons. Lester-Phoenix Inc., Cleveland.

Welding

Air-operated press welders. Available in two models—a projection welder or combination projection and spot welder when horns are used, and a spot welder with a swiveling lower horn. Taylor-Winfield Corp., Warren, O.

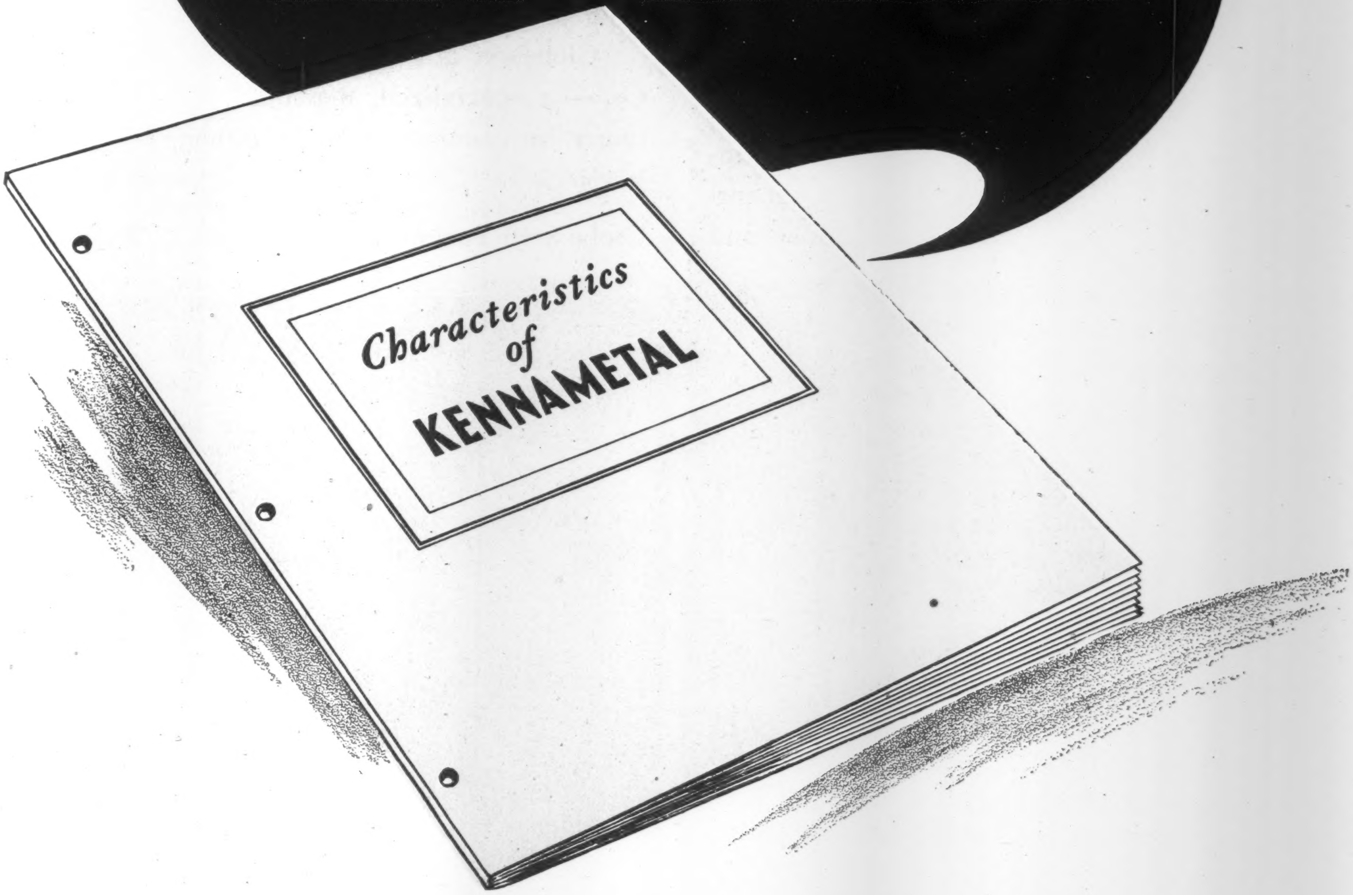
High-speed spot welder for dust-shields on right and left fenders. Can also handle two different sized fenders interchangeably. Operates at rate of 150 assemblies per hour with 18 spot welds per fender. Progressive Welder Co., Detroit.

Powder metallizing unit, known as "Spraywelder", permits both metallizing and welding procedures. In the first part of process it applies overlay of hard-facing alloy. Then used as a conventional welding torch to fuse sprayed overlay to base metal. Wall Colmonoy Corp., Detroit 3.

Air-operated portable gun welder. Has double-acting air cylinder inside construction, between lever arms, transmitting pressure to electrodes by lever action. Suitable for welding light-gage sheet metal, but will also weld heavier work when supplied with short holders. Eisler Engineering Co. Inc., Newark 3, N. J.

Arc positioner, an automatic shielded arc welding head, traveling on a beam that encompasses a vertical zone of 8 ft, with the assembly rotating around a fixed axis to a maximum radius of 20 ft. Available in three sizes. Total assembly manufactured by Mark F. Gouran, Philadelphia; while traveling assembly is made by Lincoln Electric Co., Cleveland.

A Helpful New Book for
PRODUCT DESIGNERS and DEVELOPMENT ENGINEERS



Describes the versatile cemented carbide—Kennametal—and outlines the distinguishing characteristics of the several compositions available, each having its specific use.

Tabulates mechanical and physical properties—hardness; Young's modulus of elasticity; transverse rupture, compressive, and torsion strengths; specific gravity; thermal and electrical conductivity; coefficient of thermal expansion; magnetic permeability.

Suggests distinctive advantages for use as a wear-resistant material on elements of apparatus where outstanding resistance to abrasion, corrosion, high temperature, and deformation is highly desirable; and gives application hints.

IF. . . *you are interested in Kennametal for wear applications send for a free copy of this book.*

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SUPERIOR CEMENTED CARBIDES
KENNAMETAL *Inc.*, LATROBE, PA.

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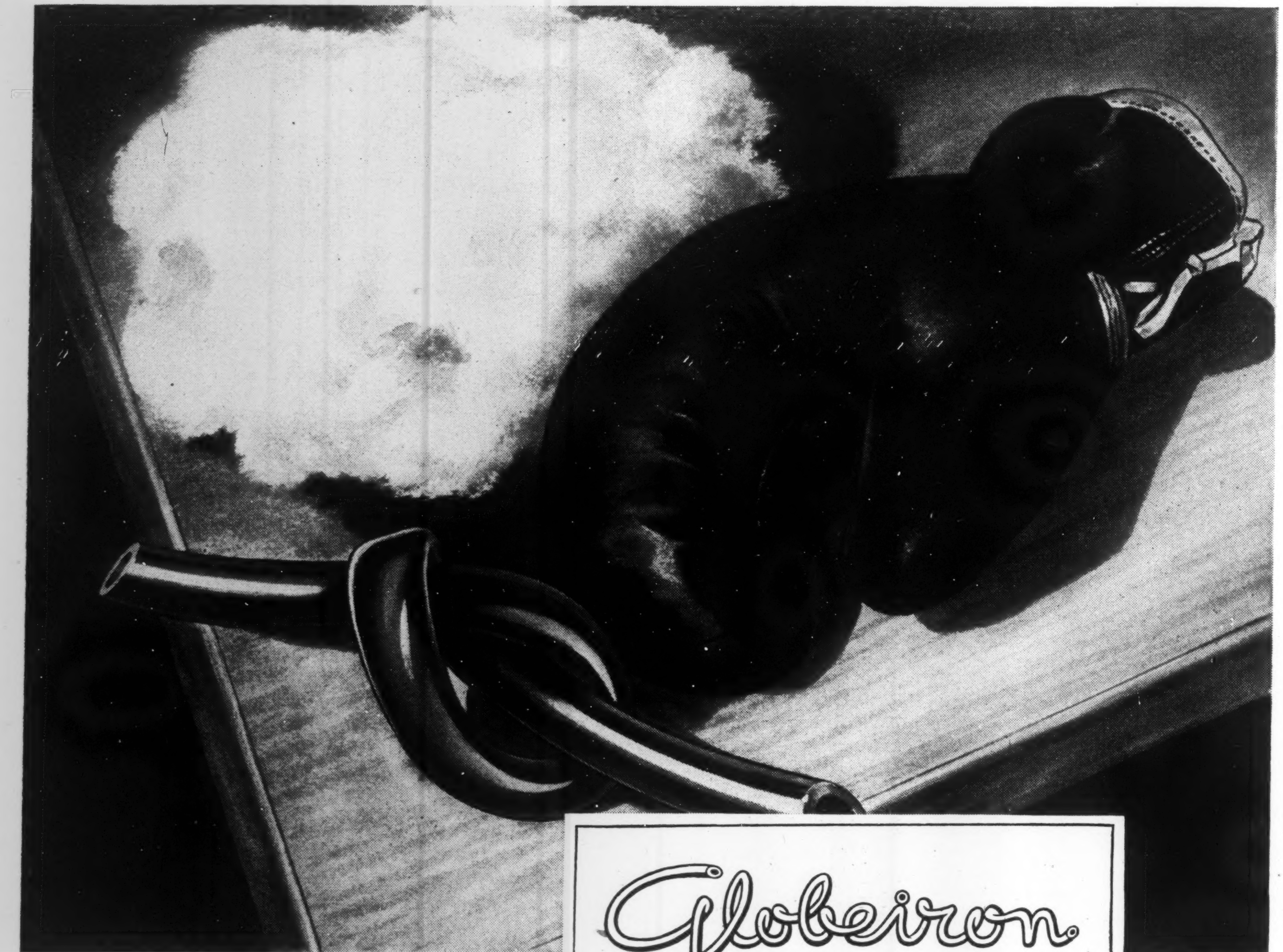
Globeiron is superior to many steels in corrosion resistance — in any applications wherever corrosive attack is accelerated by segregations and impurities in steels. It may be hot-worked in any temperature range without becoming brittle. Pressure tube requirements, where uniformity, ductility and purity of metal are essential, can best be met with Globeiron seamless tubing.

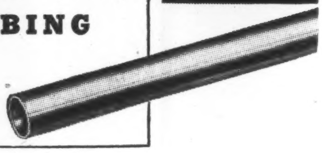
Globeiron is a product of Globe Steel Tubes Co. — a specialized, dependable manufacturing source for seamless tubing in carbon, alloy, stainless steels, and Gloweld welded stainless steel tubing.

Globe Steel Tubes Co. • Milwaukee 4, Wisconsin.

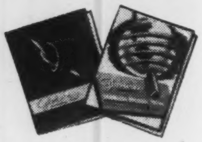


Globeiron

SEAMLESS TUBING



Write for Globeiron Bulletins Nos. 109A and 113



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Install a Veeder-Root Counting Device that will give direct and accurate *Count*rol over rate of feed, depth of cut, or any other phase of operation.

Then operators and inspectors get their Facts-in-Figures directly, plainly, *unmistakably* . . . in bold, easy-to-read figures that don't have to be converted, decoded, or otherwise translated.

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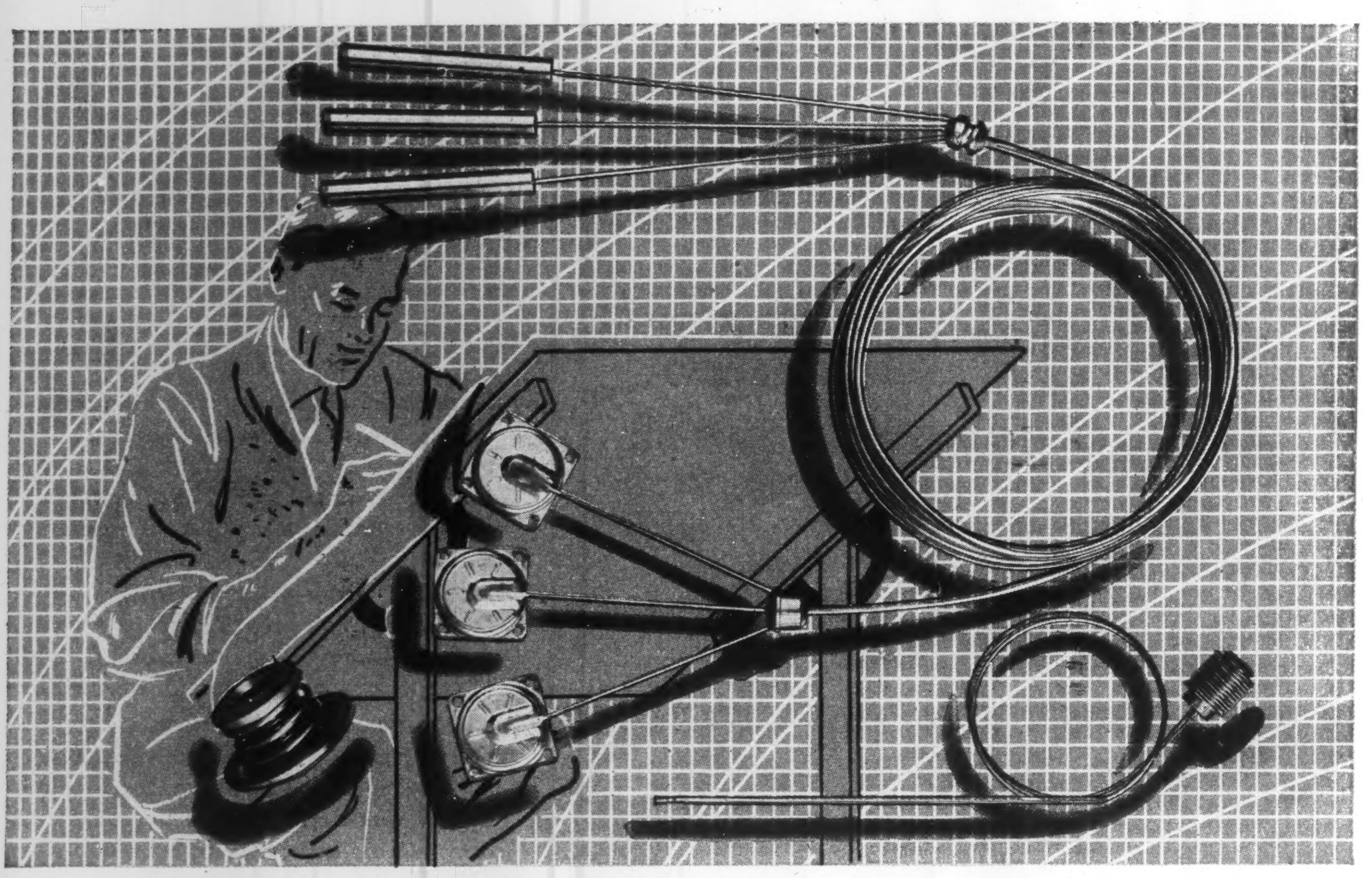

Hydron Bellows Assemblies Engineered To Specifications

If you depend on the smooth functioning of a bellows to control temperature or pressure, to compensate for altitude changes, to seal gases or liquids under pressure, etc., consider the advantages of purchasing *complete* bellows assemblies.

COMPLETE ASSEMBLIES SAVE TIME, TROUBLE AND MONEY

Many metallurgical, mechanical and chemical variables enter into the engineering of a bellows assembly. So, by placing complete responsibility in one source you lessen the chances of error, get faster service and profit from your supplier's equipment investment and trained personnel.

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Specializing in the production of bellows and bellows assemblies designed for use and installation by our customers in products of their own manufacture, we have the equipment, skill and experience to engineer your unit *right* from initial sketch to final installation. Submit specifications for recommendations and quotations.

CLIFFORD MANUFACTURING COMPANY, 566 E. First St.,
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First with the Facts on Hydraulically-Formed Bellows

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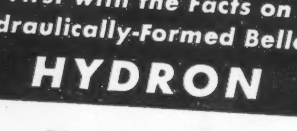
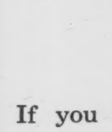
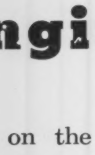


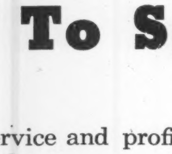
Feather-Weight . . . The First All-Aluminum Aircraft Oil Coolers . . . Made of Hydron Tubing Brazed by our Patented Method.

Offices in Detroit, Chicago and Los Angeles


Instrument Bellows


Aircraft Bellows Assembly

Steam Trap Bellows Assembly


Bellows Seal Assembly

All-Aluminum Cylindrical Oil Cooler

All-Aluminum Oval Oil Cooler

Compensate for stresses and strains that cause looseness of BOLTED PARTS

Vibration, ductility of metal, expansion, contraction and wear inevitably loosen component parts of bolted assemblies.

Only Spring Lock Washers adequately counteract looseness due to dimensional changes which cause loss of tension in bolted assemblies. That's why most Product Engineers specify Spring Lock Washers wherever bolt tightness is vital. "Products Efficiently Engineered Are Spring Lock Washer Equipped"

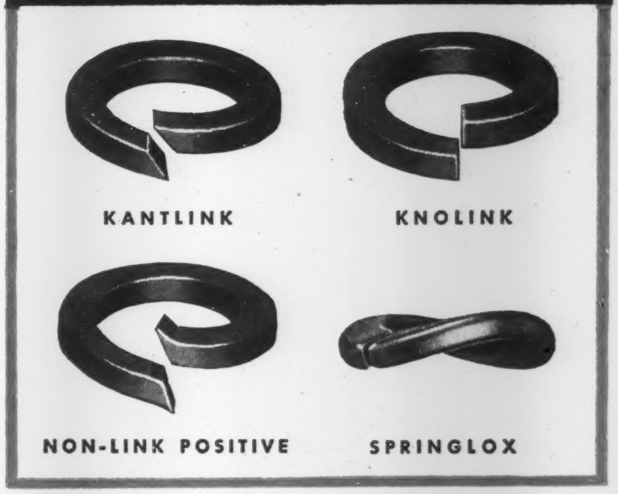
Use RELIANCE *spring* LOCK WASHERS

Reliance Spring Lock Washers are produced from correct steel sections for the application. They are made from special-analysis alloy steel, produced in Reliance's own steel mill under the supervision of experienced Reliance personnel. They are manufactured to rigid specification and their fabrication is carefully controlled from raw material to finished product, giving an added factor of protection.

Reliance Spring Lock Washers are approved and specified by the Society of Automotive Engineers, American Standards Association, American Society of Mechanical Engineers, government agencies and large industrial users.

Write for Folder 5A for additional information.

A FEW OF THE MANY RELIANCE SPRING LOCK WASHERS



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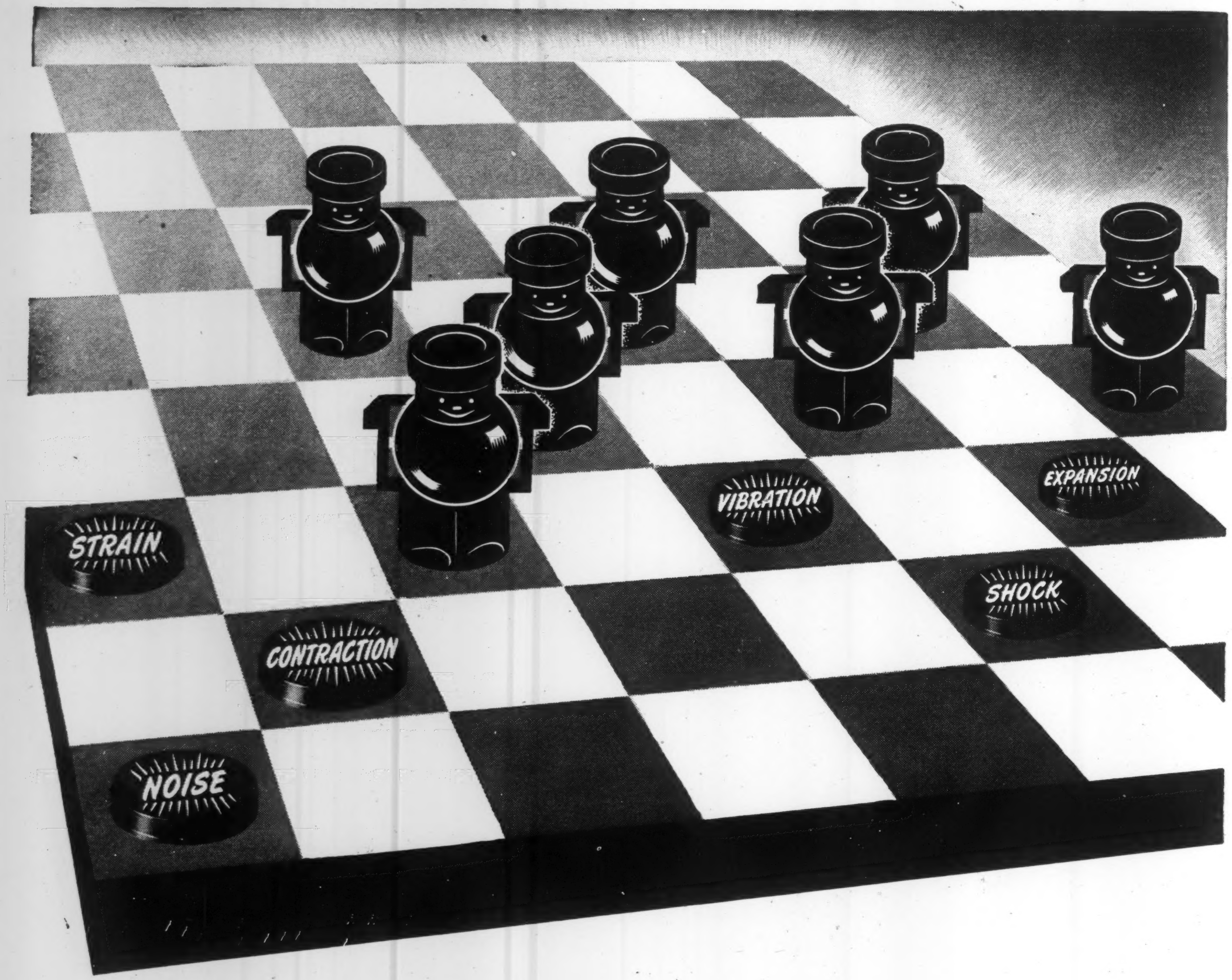
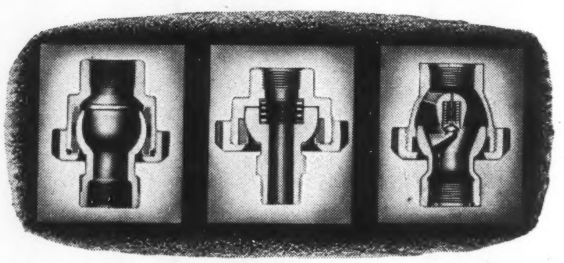


Vibration hasn't a chance with BARCO

In this game of checkers, the forces that attack fluid-conveying lines can't win. For Barco Flexible Joints not only absorb destructive vibration, but compensate for expansion and contraction, provide flexible responsive movement against shock and strain. In the Barco line you'll find the right joint for your special installation. Write for facts. Barco Manufacturing Co., Not Inc., 1806 Winnemac Avenue, Chicago 40, Illinois.



BARCO ***FLEXIBLE JOINTS***

Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movemen through every angle.

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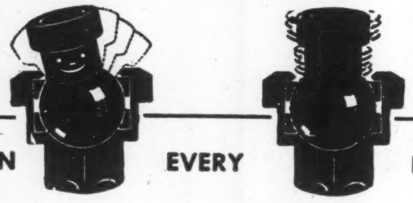


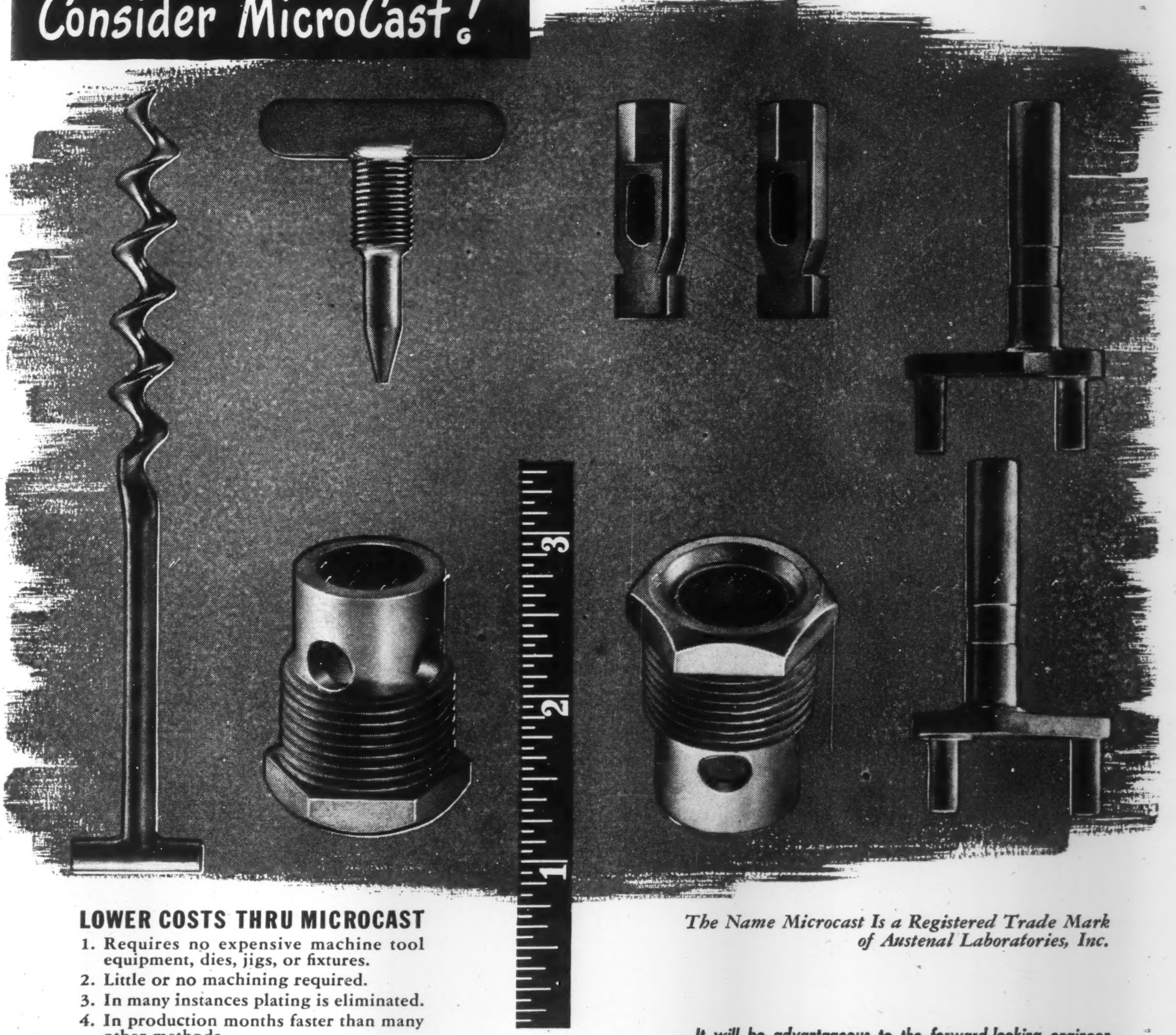
In Canada: The Holden Co., Ltd., Montreal, Canada.

"MOVE IN EVERY DIRECTION"

Where Performance Counts
ON SMALL CASTINGS

. . . Because with MICROCAST, in the production of small parts up to 4 oz., you can now use to full advantage the high melting point, non-machinable alloys which offer extreme resistance to abrasion, heat, corrosion, and maintain strength and hardness at high temperatures. MICROCAST permits the use of these alloys because even intricate shapes as cast are precision smooth, of sound structure and to such dimensional uniformity that virtually all machining is eliminated.

Consider MicroCast!



LOWER COSTS THRU MICROCAST

1. Requires no expensive machine tool equipment, dies, jigs, or fixtures.
2. Little or no machining required.
3. In many instances plating is eliminated.
4. In production months faster than many other methods.
5. Adaptable to both small and large volume production.
6. Low capital expenditure makes it ideal where design changes may be frequent.

The Name Microcast Is a Registered Trade Mark of Austenal Laboratories, Inc.

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It will be advantageous to the forward-looking engineer and production executive to investigate the possibilities of the Microcast Process. Substantial improvement in parts used in machines and equipment may follow. Austenal Laboratories will be pleased to cooperate with industry toward producing Microcastings to meet special requirements and specifications. Our present capacity is 1,000,000 Microcastings per month.

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POUGHKEEPSIE, N.Y. U.S.A.

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There's a world of difference between *still-fit* and *operating fit* in a ball bearing, especially when you're blueprinting higher R.P.M.'s into your product design. Holding run-out to a minimum is the problem in order to maintain proper running clearances. Here's a true measure of ball bearing precision... in manufacture and operation both.

At Federal, inner and outer races of *every* ball bearing are ground concentric with each other to prevent run-out. The bore is cylindrical, not tapered or bellmouthed, and the sides of the rings are held parallel to each other and the ball track. No Federal Bearing is either too tight or too loose.

Add to this, the ball track ground to a chatter-free finish and just the right radius, plus balls uniformly spherical within .000025″ and not varying in diameter more than .00005″ in any bearing, and you have the precision ingredients for close tolerance performance.

Over 100 individual production, cleaning and inspection operations go into every Federal Bearing, and *every fourth operator is an inspector*... all good reasons why, *whenever tolerances are tight*, specify Federal Bearings for smooth running... in any range or size.

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FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

NEW! FOOLPROOF!

HANSEN

TWO-WAY SHUT-OFF COUPLING

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SEALS BOTH ENDS OF LINE—
AUTOMATICALLY...INSTANTANEOUSLY

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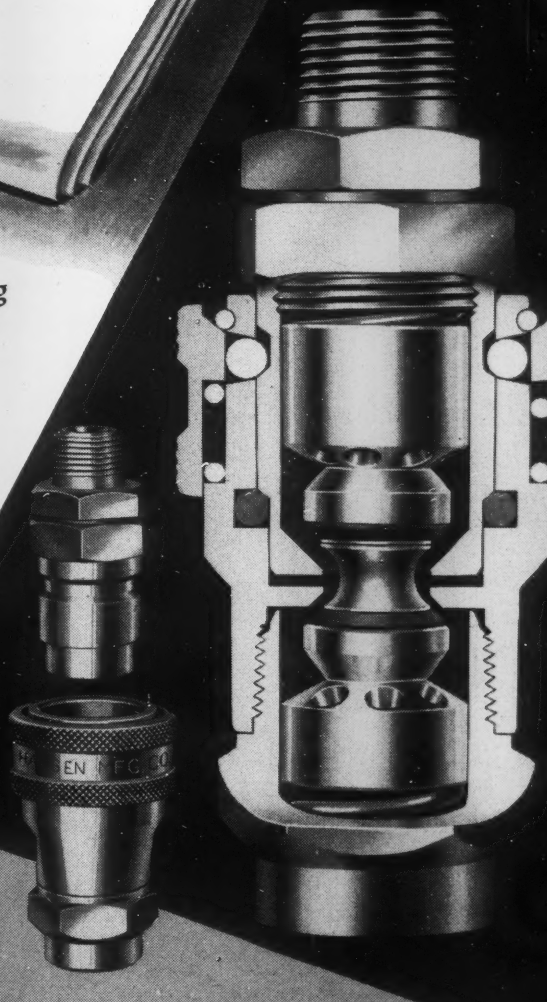

The new Hansen two-way shut-off coupling provides for easy—quick—safe connecting and disconnecting of hydraulic and pneumatic lines. This unique "spool type" valve coupling permits the instant sealing of each end of the lines immediately upon disconnection of plug from socket. To connect, you pull back sleeve and merely push plug into socket—coupling is connected and locked—valves in socket and plug are open, automatically permitting oil or gas to flow freely in either direction. To disconnect, push back sleeve — this disconnects coupling. Socket and plug are each positively sealed, automatically preventing loss or spillage of fluid. Check the many advantages in time, labor and cost savings provided in this new Hansen two-way shut-off coupling.

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T-J CYLINDERS

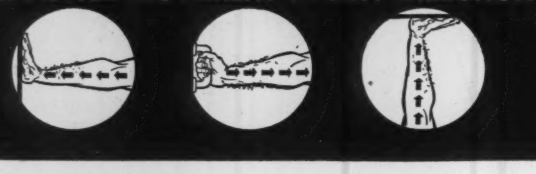
HIGH OPERATING SPEEDS

LOW AIR CONSUMPTION

In these air-operated press welders manufactured by The Taylor-Winfield Corp., Warren, Ohio, T-J Cylinders contribute to the rapid and efficient operation of the machines. The cylinder is employed to move the welding head to the work and return—a job performed by T-J with *accuracy, speed* and *dependability!*

This is typical of the widespread use of T-J Cylinders today to simplify operations and save time and labor. There's a T-J Air or Hydraulic Cylinder *exactly right* for all kinds of tough jobs where pushing, pulling or lifting is needed . . . 100 lb. or 50,000 lb. Available in many standard sizes and styles . . . both cushioned and non-cushioned types. Backed by 30 years of know-how . . . T-J engineered to do the job *better* and *cut costs!* Write for latest catalogs. The Tomkins-Johnson Co., Jackson, Mich.

FOR POWER MOVEMENT IN ANY DIRECTION



TOMKINS-JOHNSON

RIVITORS...AIR AND HYDRAULIC CYLINDERS...CUTTERS...CLINCHORS

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RACINE HYDRAULICS

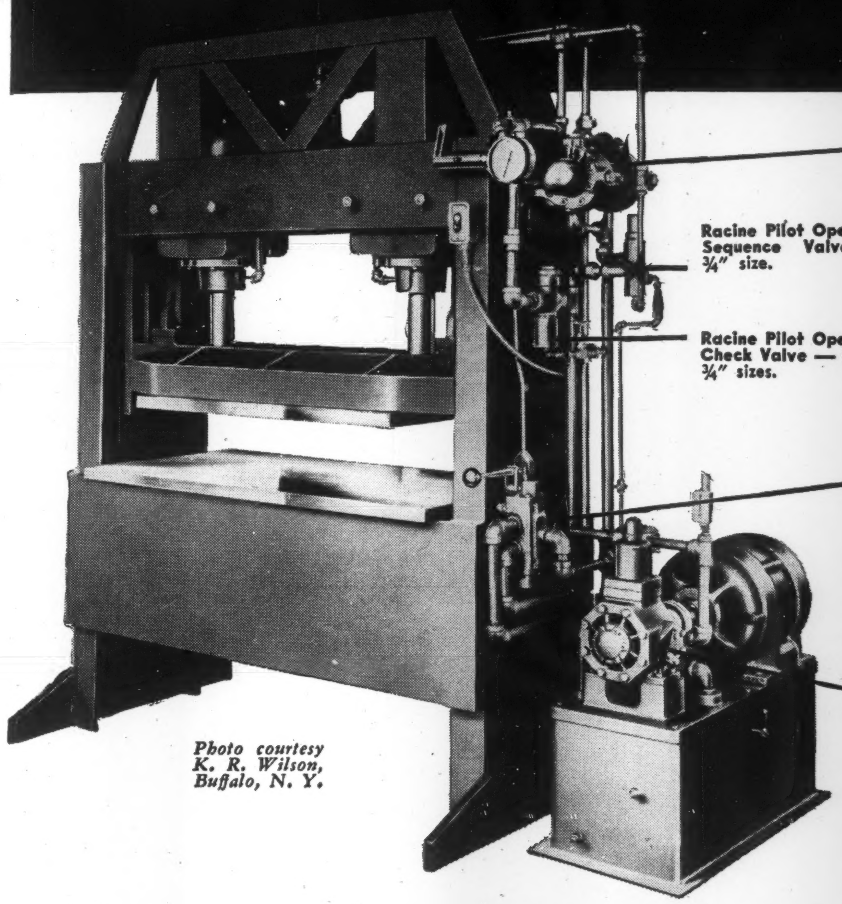
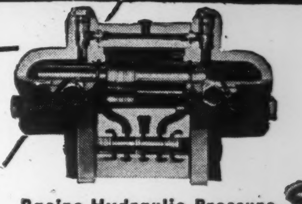


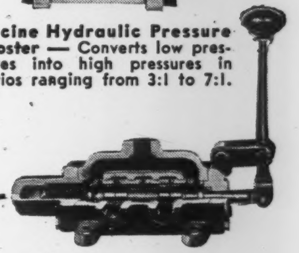
Photo courtesy K. R. Wilson, Buffalo, N. Y.

Racine Pilot Operated Sequence Valve — ¾″ size.

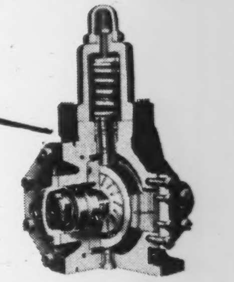
Racine Pilot Operated Check Valve — ⅜″ to ¾″ sizes.



Racine Hydraulic Pressure Booster — Converts low pressures into high pressures in ratios ranging from 3:1 to 7:1.



Racine Four-Way Hydraulic Valve — Balanced Piston — Sleeve Type construction. Manual, Mechanical and Electrical control. Sizes ⅜″ to 1½″.



Racine Variable Volume Oil Hydraulic Pump — 12 to 30 G.P.M. Pressure 50 to 1000 lbs. p.s.i.

INTEGRATED TO YOUR DESIGN . . . CENTRALIZED OR REMOTE CONTROL

Like this press manufacturer, you can readily give your products the advantage of a RACINE "Variable Volume", hydraulic circuit. This feature saves horsepower and reduces heat by simplifying the installation and eliminating unnecessary relief and bypass valves. Important savings in first cost also result.

RACINE Hydraulic Engineers have developed hydraulic operation and control for hundreds of machines and tools. Their experience can be helpful in applying "RACINE Hydraulics" to your present product and on new designs now in the development stage. They will cheerfully review your problems in power movement, without cost or obligation.

Let us submit detailed recommendations and circuits employing pressures as high as 3000 lbs. p.s.i. Utilize the Variable Volume feature of RACINE Pumps and easy operating, long-lived RACINE sleeve-type valves. Ask for RACINE catalog P-10-C today. RACINE TOOL AND MACHINE COMPANY, 1773 State St., Racine, Wisconsin.

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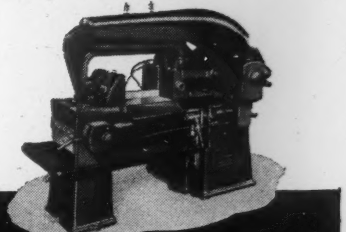
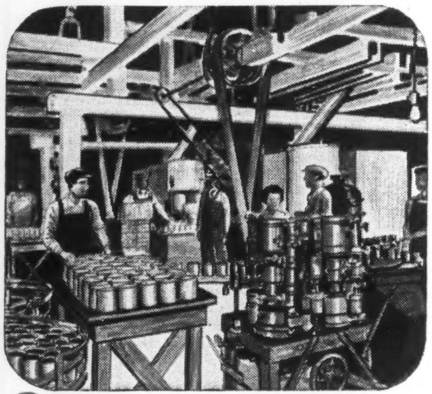
A complete line in capacities 6″ x 6″ to 20″ x 20″. Models in all price ranges — featuring simple one lever control — open front design — progressive feed for cutting any metal from light tubings to structural shapes and billets of tough tool steels. Write for complete catalog No. 12.



RACINE *STANDARD FOR QUALITY AND PRECISION*

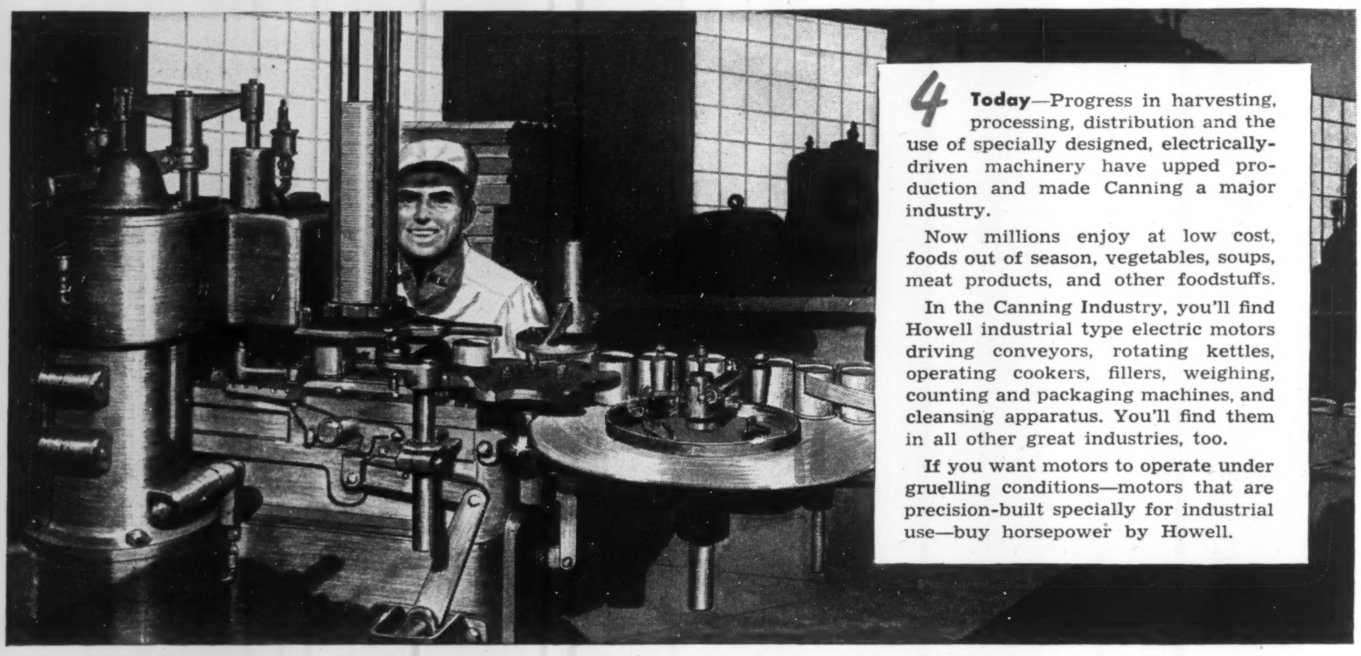
1 **1809**—"Canning" was discovered by Nicolas Appert, a Frenchman. His crude food preserving methods, using bottles for containers, won for him great acclaim and a grant of 12,000 francs from the Emperor Napoleon.

2 **1850**—The art of canning had spread far and wide. In home kitchens, barns, crude buildings, food was "preserved" for future use. Work was done by hand, mostly by women. Electrical horsepower was still to come.



3 **As early as 1915,** Howell engineers were working with machinery manufacturers to apply industrial type motors that were destined to up production, eliminate unnecessary human handling of foodstuff and cut costs.

Then canning became a major industry!



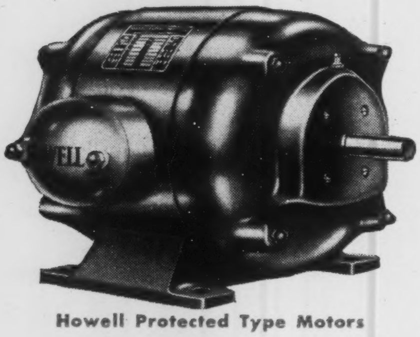
4 **Today**—Progress in harvesting, processing, distribution and the use of specially designed, electrically-driven machinery have upped production and made Canning a major industry.

Now millions enjoy at low cost, foods out of season, vegetables, soups, meat products, and other foodstuffs.

In the Canning Industry, you'll find Howell industrial type electric motors driving conveyors, rotating kettles, operating cookers, fillers, weighing, counting and packaging machines, and cleansing apparatus. You'll find them in all other great industries, too.

If you want motors to operate under gruelling conditions—motors that are precision-built specially for industrial use—buy horsepower by Howell.

Be wise—buy industrial type Howell Motors! They're designed for the toughest tasks in industry; consequently, they perform better on *all jobs!*

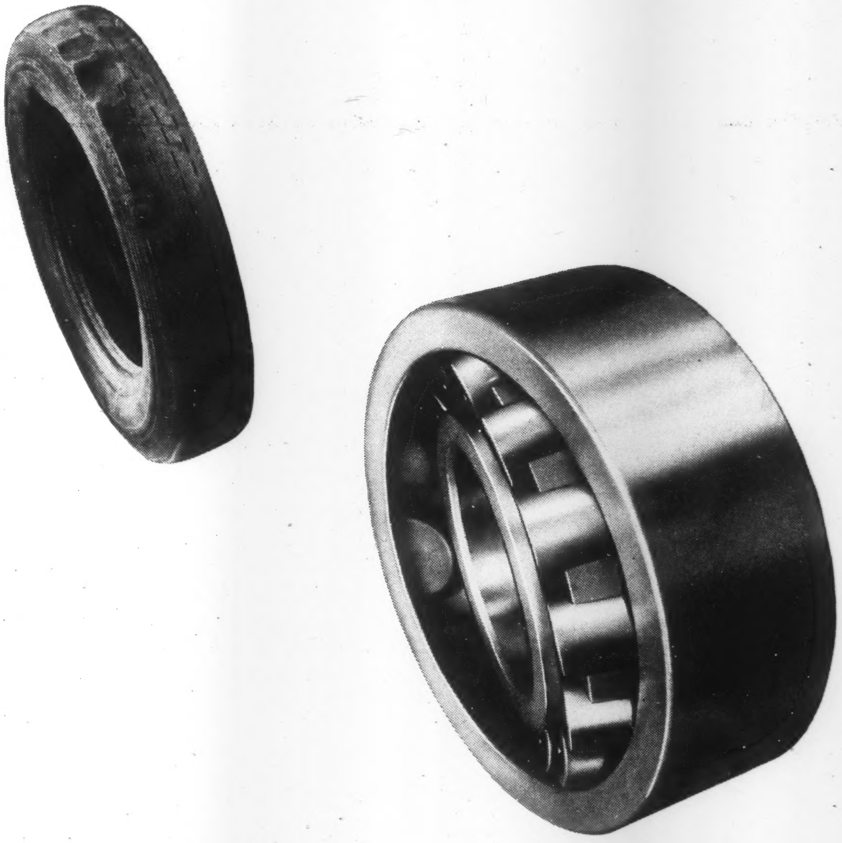


Howell Protected Type Motors

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Manufacturers of Quality Industrial Type Motors Since 1915



Mis-alignment that causes wear . . .

can happen in bearings just as it occurs in an automobile tire when the wheel is "out-of-line." Rapid wear, friction, and stresses caused by mis-alignment can result in premature bearing failure. These factors can be

Eliminated with self-aligning bearings

The Torrington *Spherical* Roller Bearing is self-aligning. Any mis-alignment due to shaft deflection, lack of rigidity or other cause is compensated by the bearing itself—without lessening its radial or thrust capacity.

This unique feature of the *Spherical* Roller Bearing is responsible for its rapidly increasing use. If you do not have a copy of our Technical Bulletin #200 on this newest addition to the line of Torrington Bearings, a request on your letterhead will bring you a copy promptly.

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Cost of machine frame reduced 50% by change to welded design

BY LOUIS FAULB, PRESIDENT
KLEEN-KUT MANUFACTURING COMPANY
CLEVELAND, OHIO

Production cost of the frame of the Kleen-Kut meat saw manufactured by our company has been reduced more than 50% by redesigning it for fabrication by arc welding. The former design and the latest welded design are shown in Fig. 1.

The new design has reduced machining operations 60%, has made the machine six times as rigid, cut its weight from 550 to 350 pounds, and has doubled the production output of the same floor area.

The changeover to all-welded design was an evolutionary process over an 18-month period.

We started with the table frame shown in Fig. 3, and the cost reduction encouraged us to redesign the whole machine. Since our original all-welded design, we have made 40 improvements. If we had used conventional fabricating methods, 40 modifications or complete changes in patterns would have been necessary. Open views of the original welded design and the latest welded design are shown in Fig. 2.

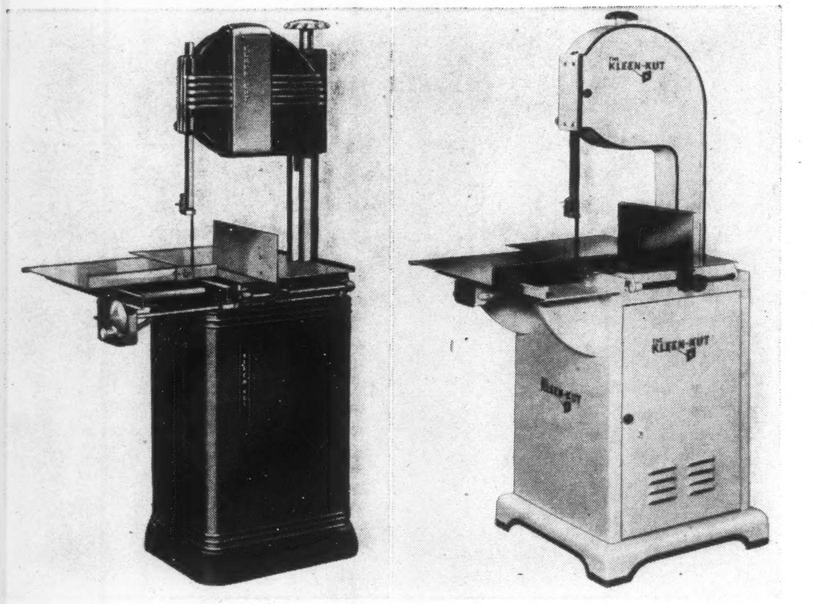

Fig. 1. Saw of former conventional design (left) and all-welded design (right).

IMPROVES THE PRODUCT

Welded design has increased the saw's overall rigidity and strength. The top pulley support, subject to considerable stresses, was stiffened by simply welding a 32-inch length of angle vertically inside the housing. Rigidity was further aided by widening the main frame to the full length of the base and redesigning the door.

Adjusting the saw blade tension in the former model required moving the entire head of the unit up or down, which took too much time. In the new design this adjustment is made by simply turning a rod. To incorporate this feature in the former design would have meant an excessive amount of machining.

INTERMITTENT WELDS USED

The new saw frame is made largely of formed plates, reinforced at strategic stress points with gussets and cross-braces. A minimum of material and welding is used, most parts being fused with intermittent welds like those in the table frame (Fig. 3). This type of welding obtains proper strength, avoids distortion and speeds production.

The table frame is constructed of 1½-inch angles with ½-inch bearing brace. The machine base consists of four ¼-inch plates joined by fillet welds in open corner joints. The main stand is $\frac{3}{16}$-inch-thick steel sheet with inside fillet joints. Bearing and pin bosses are solid welded into the structure. Hinged covers are 14 gauge steel sheet.

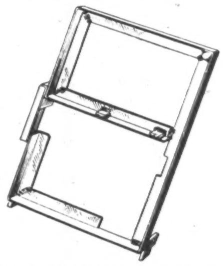

Fig. 3. Table frame, made from angles. This is the first part that was changed to welded design.

Wherever possible, welding is done on the inside of the joint to give a smooth exterior appearance. Because materials are light-weight, all parts can be easily handled for bench-welding.

The reduction in machining operations has enabled us to double our production within the same floor area. Materials-procurement has also been simplified. Previously we ordered parts from seven outside firms; now we make them all in our own plant with simple, low-cost production facilities.

In approaching redesigning problems, our engineers have been aided by the Studies in Machine Design issued periodically by The Lincoln Electric Company. These are available free to engineers and designers who write The Lincoln Electric Company, Dept. 352, Cleveland 1, Ohio.

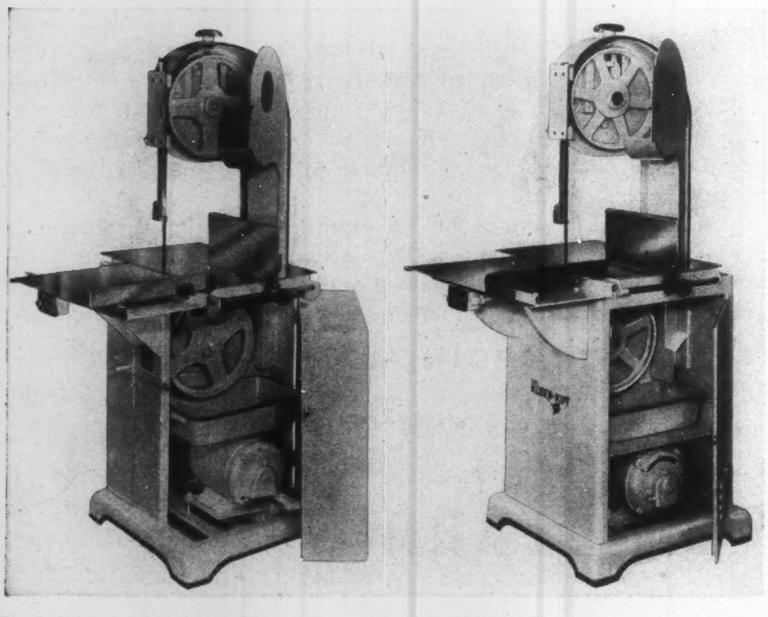

Fig. 2. Original welded design (left) and latest welded design (right) with covers open to show interiors.

(Advertisement)

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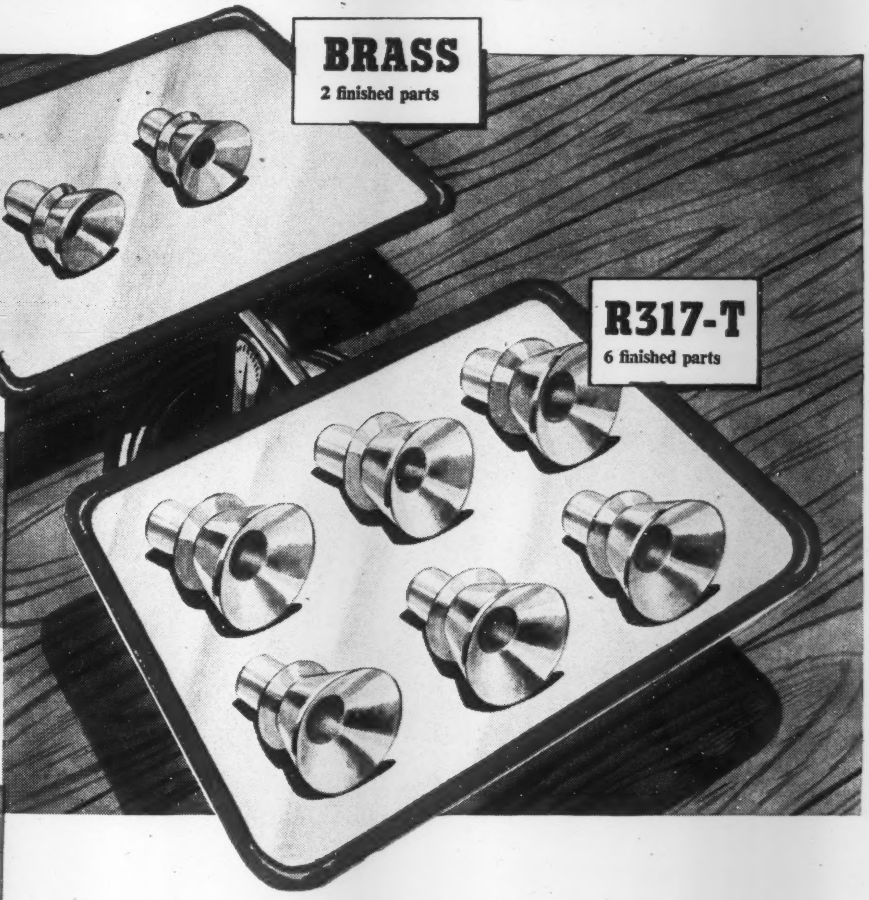
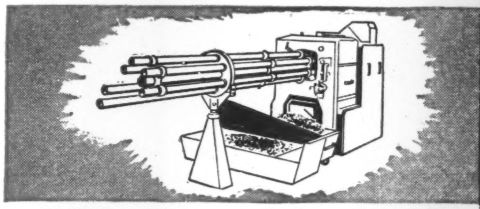
...get 3 times as many finished parts!

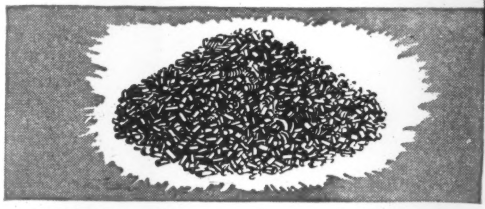


HIGHER SPEEDS



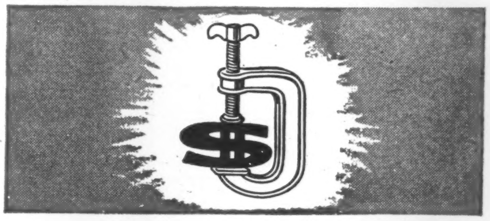
R317-T can be run at high-profit speeds, comparable or in some cases, higher speeds than brass.

CLOSER TOLERANCES



R317-T machines easily to a bright, natural finish. Forms small chips. Does not run with the tool. May be worked to very close limits.

LOWER-COST MACHINING



Accurate volume production with fewer rejects. Result: lower cost, more profit per finished part.

Yes—thanks to the favorable weight factor aluminum gives you three times as many finished parts per pound as brass. By the foot you pay less for aluminum than you do for brass. All of which adds up to a saving of about 50% in material cost.

For high speeds, excellent machinability, a bright, natural machine finish and LOWER COSTS, use R317-T, Reynolds new aluminum screw machine stock. Only a fraction of the cost per finished piece as R317-T weighs only ⅓ as much as brass (and other heavy nonferrous metals).

Order now. R317-T is ready for immediate shipment from Louisville warehouse stock in rounds and hexagons in all standard sizes. 17S-T, Reynolds standard screw machine stock, is also available now.

Consult Reynolds. Reynolds is ready to work with your engineers. Offices in principal cities. Phone nearest office . . . or write Reynolds Metals Company, Aluminum Division, 2521 South Third Street, Louisville 1, Kentucky. See Sweet's or write for Catalog 100-B "Reynolds Aluminum—Available now for Today's Products."

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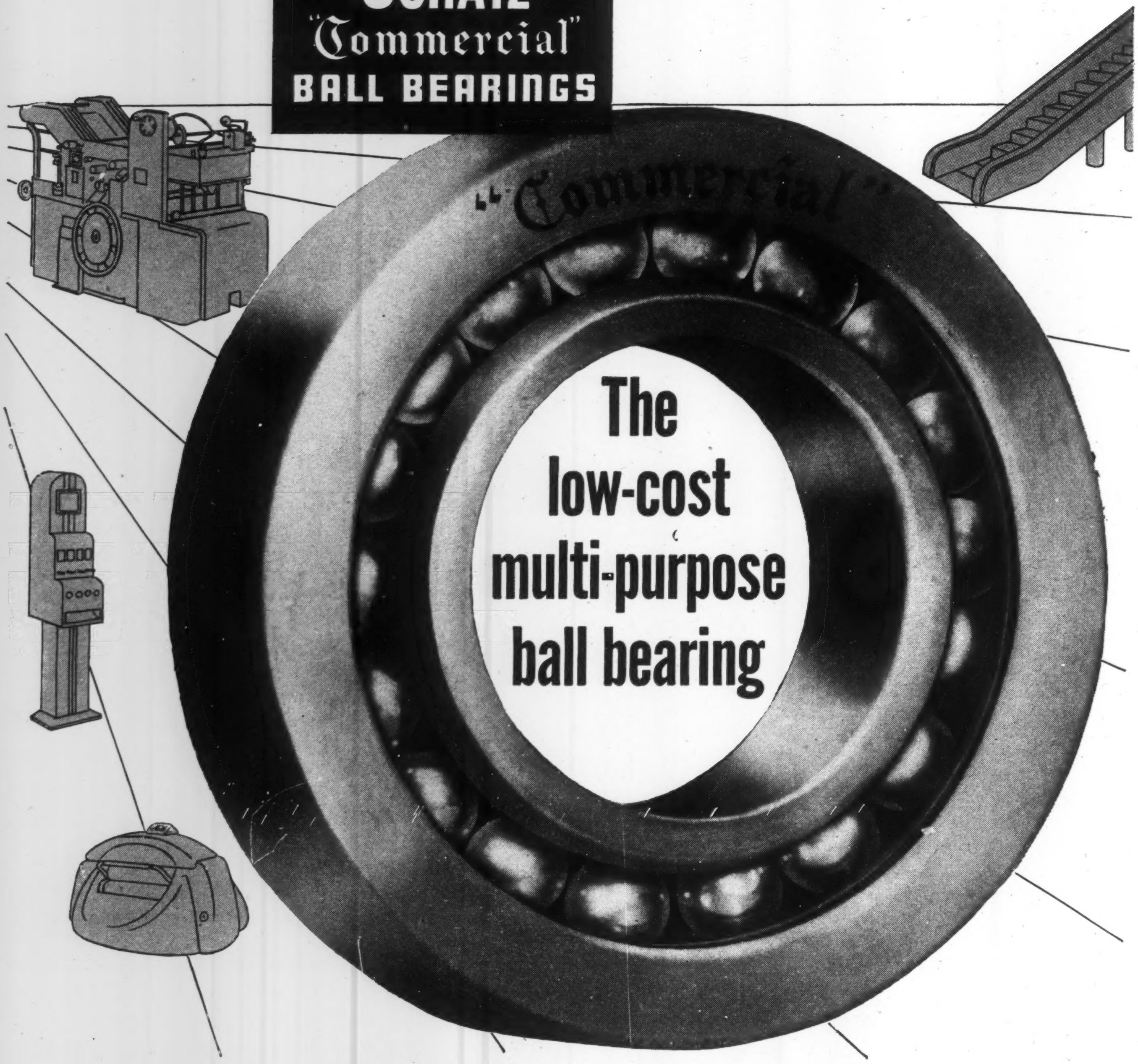

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"Commercial" Ball Bearings are manufactured in every standard type and size. The common denominator in each is the half-century of Schatz manufacturing experience, plus the engineering counsel that's ready to lend a knowing hand and fit the right bearing to your application.

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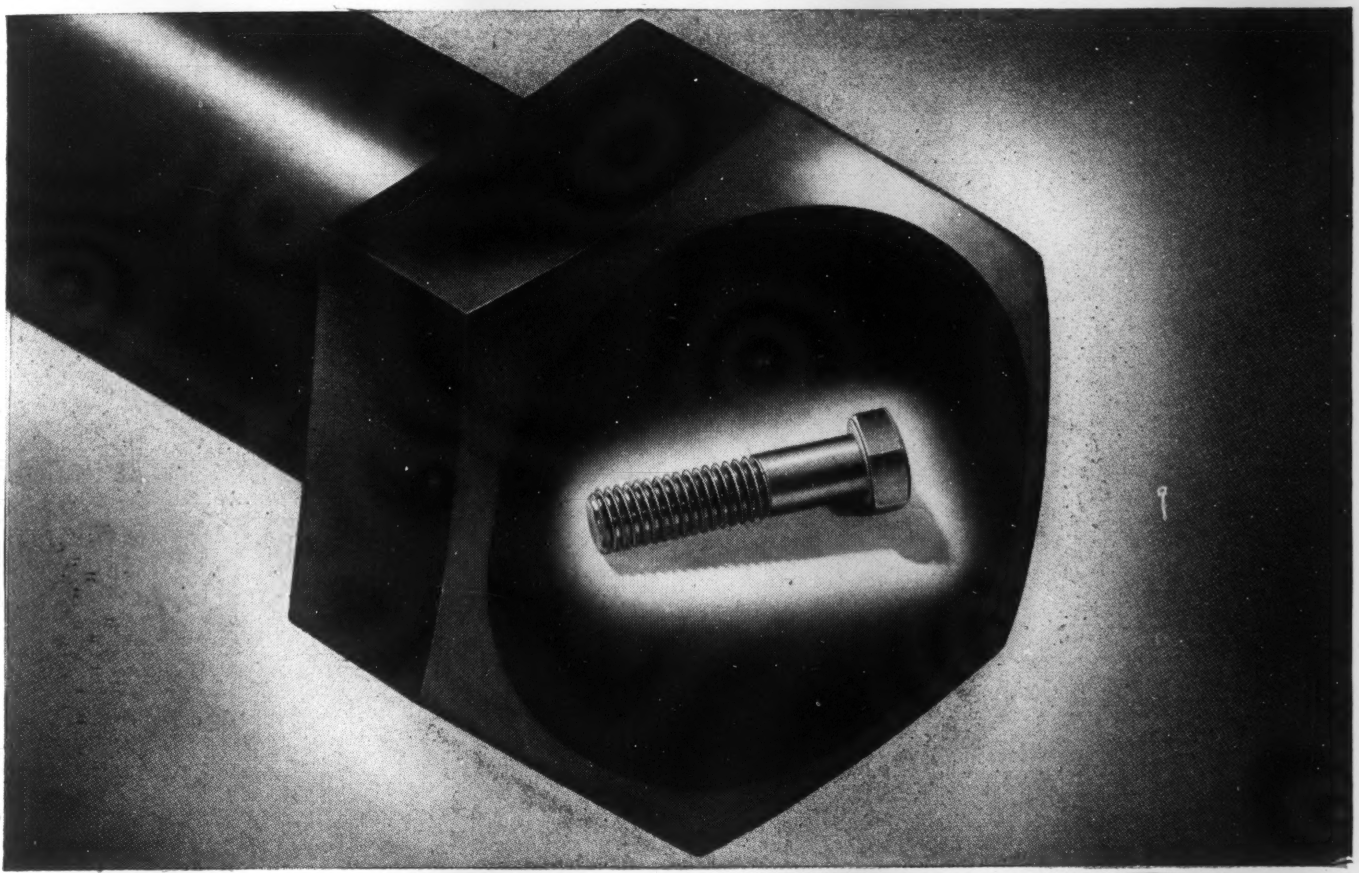

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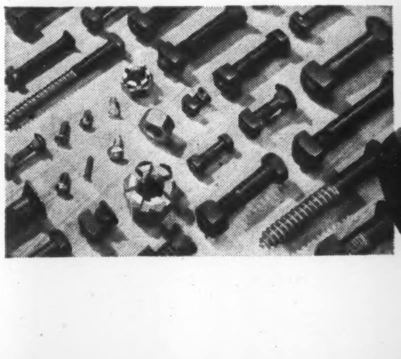

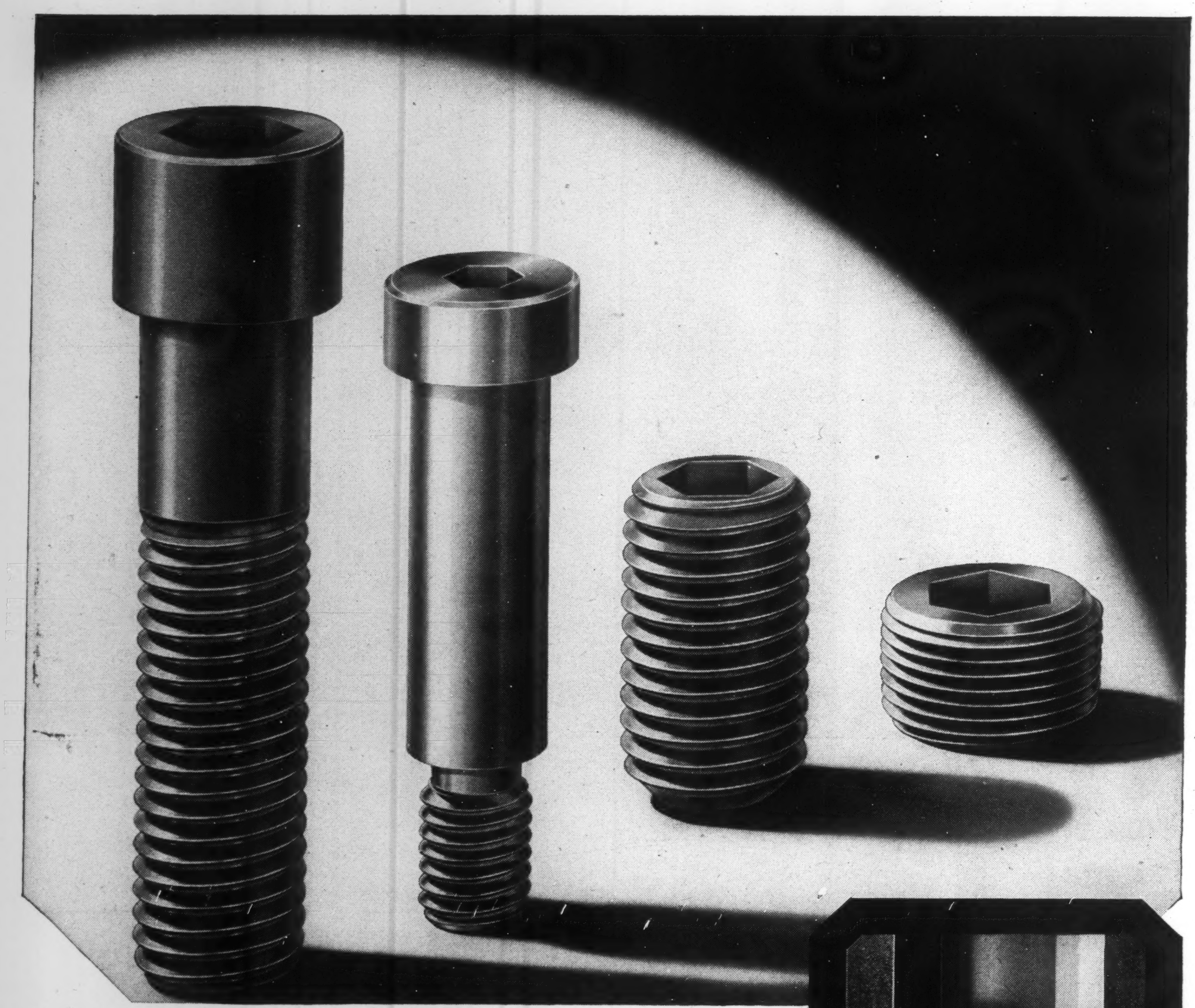

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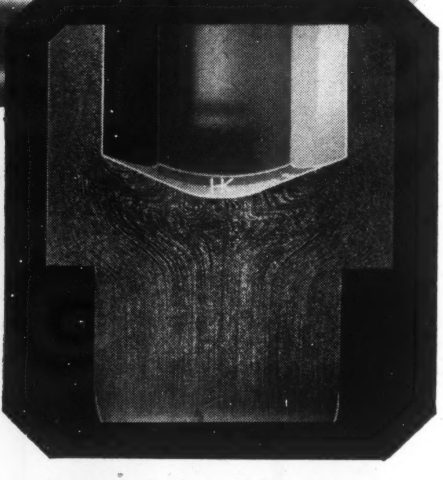

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"Welding Aluminum"—Gives detailed information on the 11 aluminum welding processes from edge preparation to finishing. Fully illustrated with photographs, chart and tables.

ANSWER: Oxidation and apparent weakness of aluminum at high temperatures.

2. QUESTION: When drilling a hole to be machine-reamed in aluminum alloys, how do you figure the proper allowance?

"Machining Aluminum Alloys"—124 pages packed with practical up-to-date facts. Eight double-page charts of easily usable data on tooling, speeds, and feeds, for eight important types of machining operations.

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3. QUESTION: What are the three main types of anneals used with aluminum alloys?

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ANSWER: Horizontal bulk anneal, vertical anneal, flash anneal.

4. QUESTION: How many Reynolds alloys are produced in forging stock?

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ANSWER: Eight—14S, 17S, 18S, 25S, 32S, A51S, R317, R353.

IF you work with aluminum or its alloys, some of these problems are familiar to you . . . some you may have to solve in the future.

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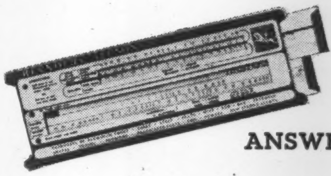

"Metals Weight Calculator"—Simple . . . accurate . . . fast. Calculates the weights of aluminum, magnesium, steel, brass, copper and nickel in various forms (sheet, rod, etc.). Range—from .0006 lbs. to 3,000 lbs.

ANSWER: Use the Reynolds Weight Calculator.

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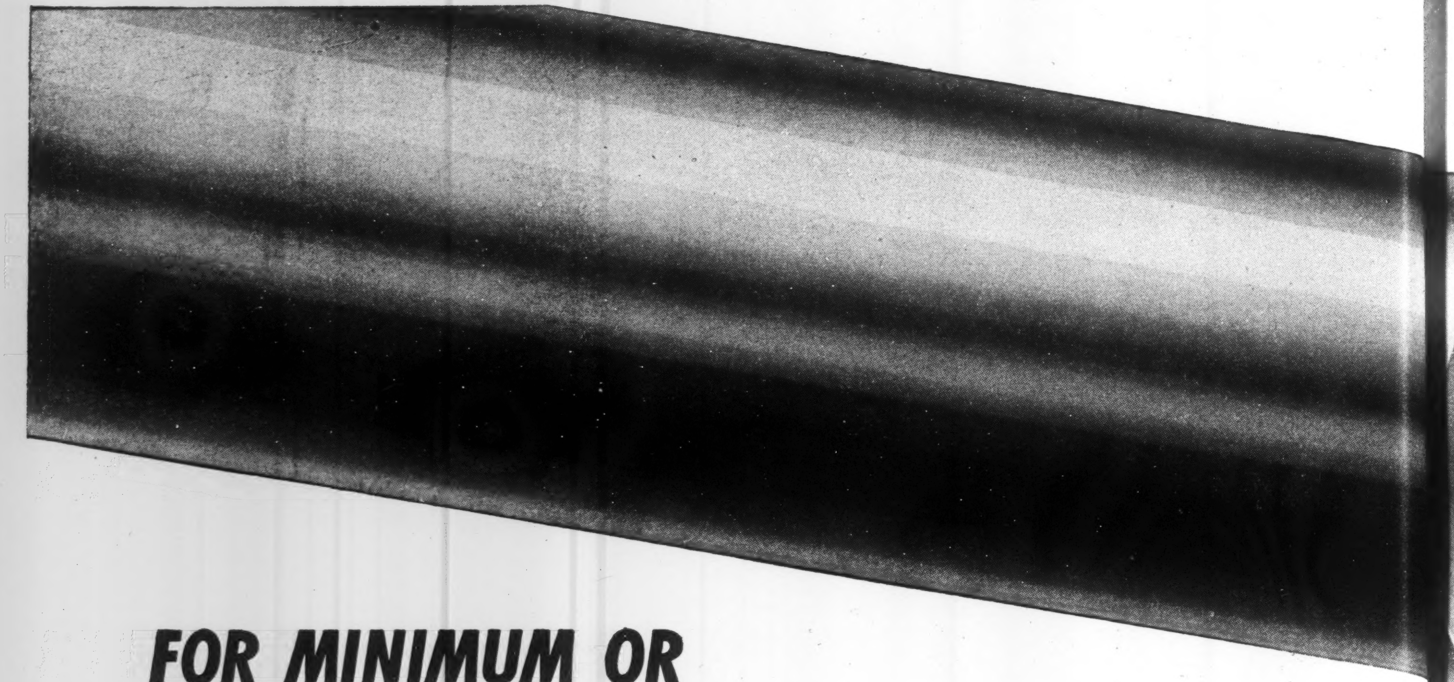

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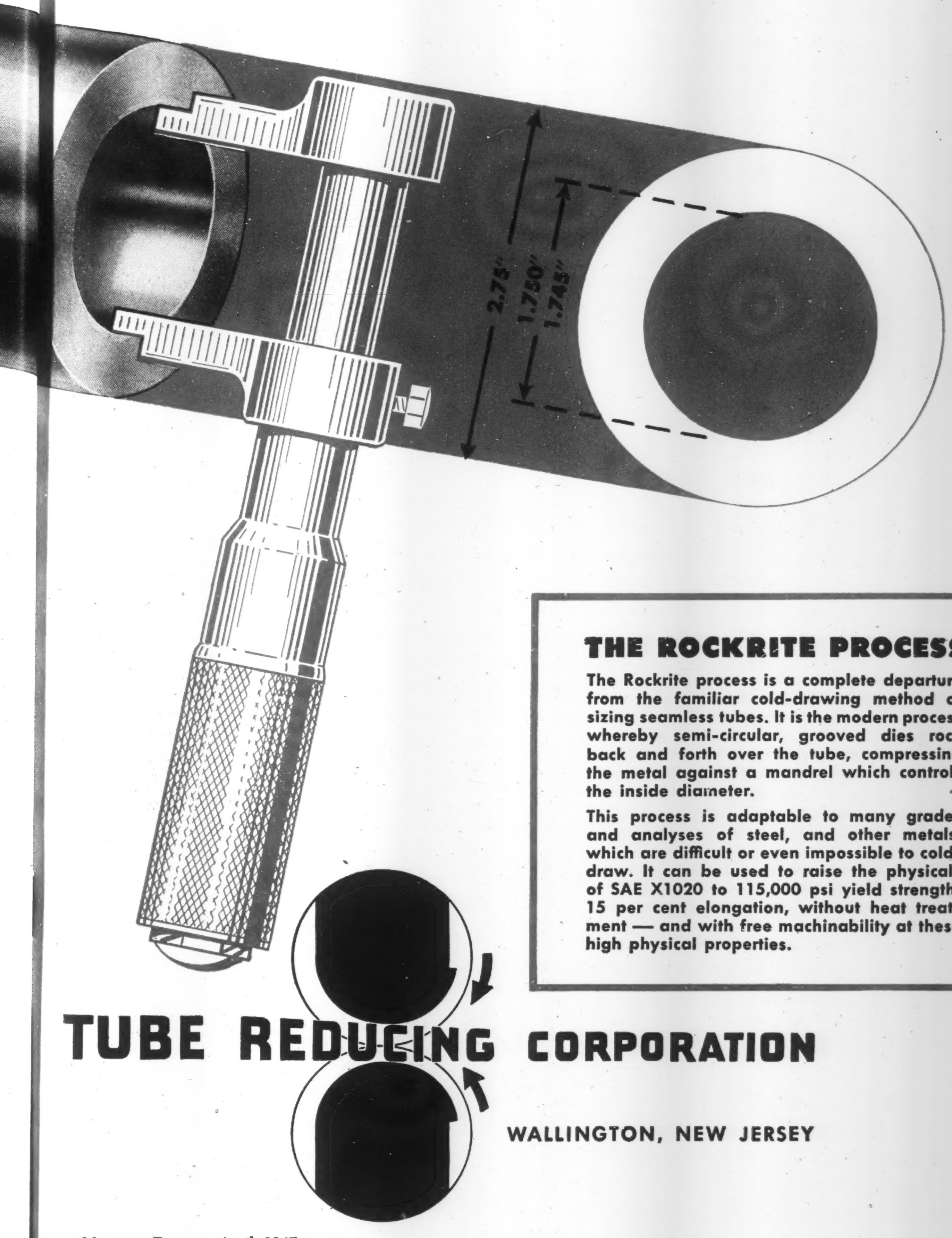

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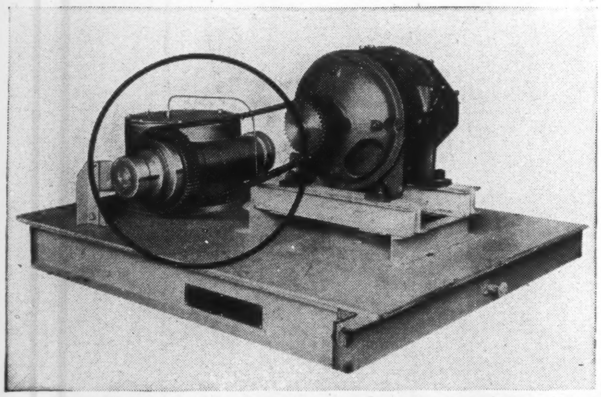
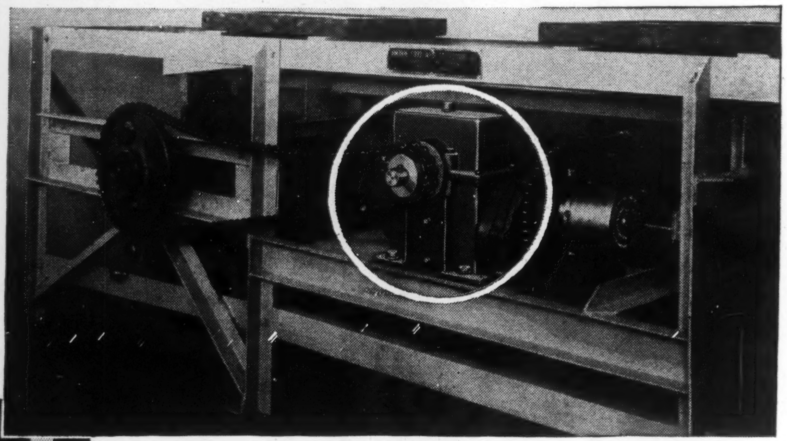


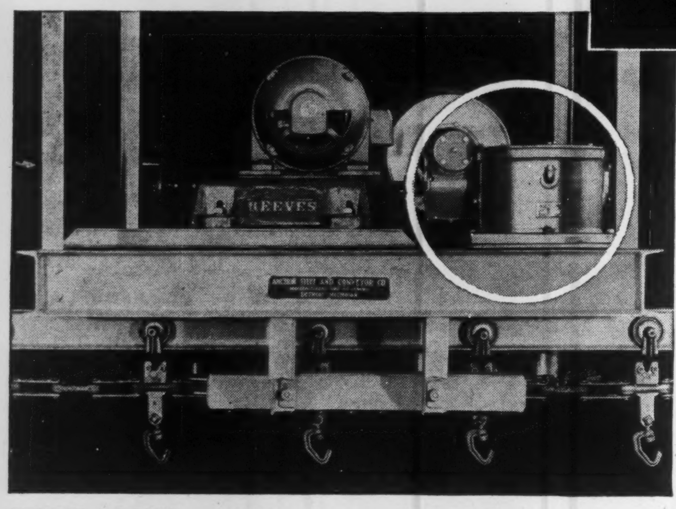
MODEL 8 BV
Ratio 40:1

WHS Vertical speed reducer used on an Overhead Conveyor drive protected by "Anchor" Overload Safety Cut-out.



MODEL 8 BX 90 to 1 ratio . . . an integral part of an Anchor Floor Conveyor drive.

The capacity of regular stock model WHS Worm Gear Speed Reducers to meet **diversified requirements** is seldom better illustrated than in the drives on these . . . and other Anchor Overhead Conveyors. The experience of this WHS customer bears out again our oft-repeated statement that "There is a WHS Speed Reducer for every speed reducer application". WHS gives you not only **versatility of performance** but **dependability of operation** under severest conditions.



MODEL 8 BDV Ratio 3080 to 1, as applied on Anchor Caterpillar drive for Overhead Conveyor, 2000 lb. chain pull capacity, conveyor speed 3 to 8 inches per minute.

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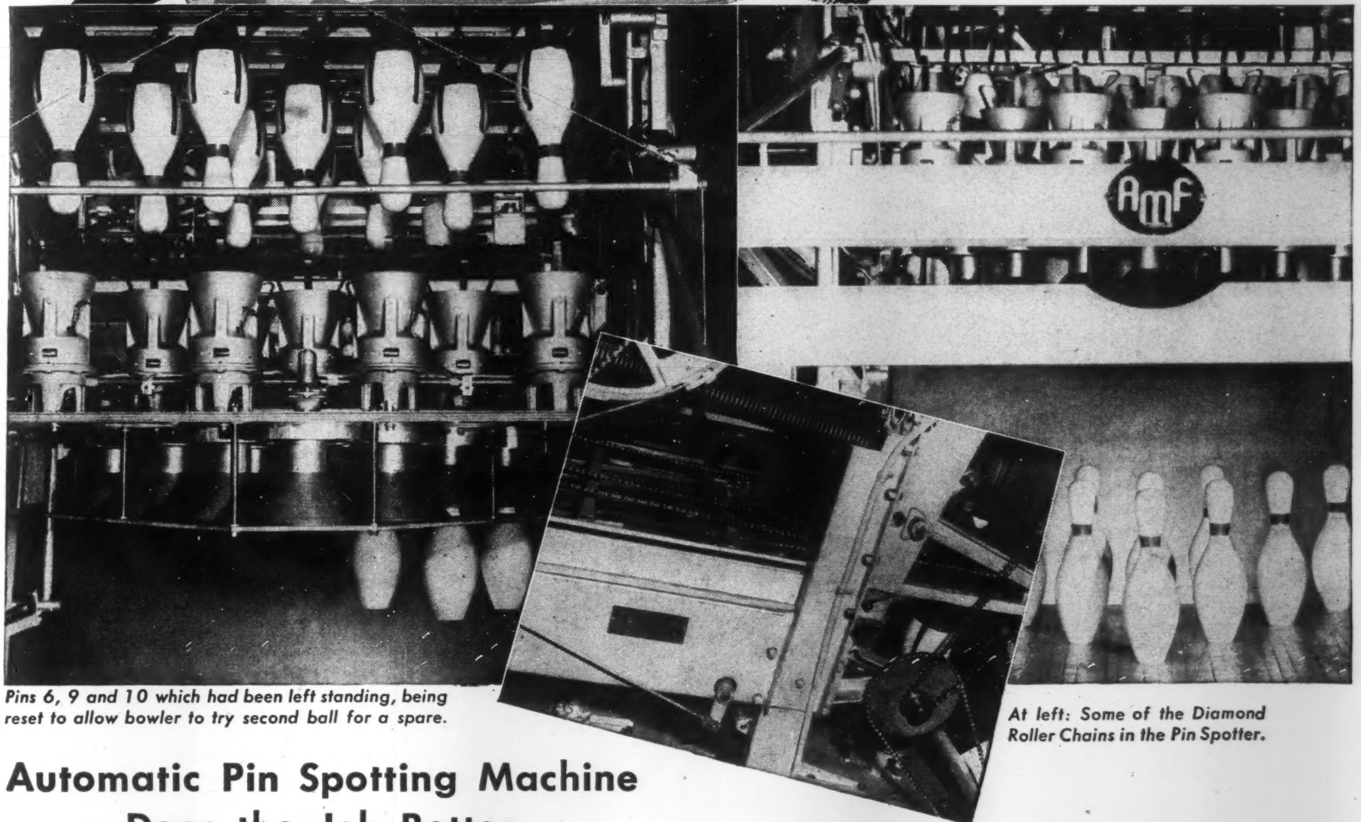


Pins 6, 9 and 10 which had been left standing, being reset to allow bowler to try second ball for a spare.

At left: Some of the Diamond Roller Chains in the Pin Spotter.

Automatic Pin Spotting Machine Does the Job Better

● Bowling enthusiasts and alley operators are well aware of Pin Boy troubles and shortages. The AMF Automatic Pin Spotter, approved by the American Bowling Congress, eliminates these troubles. It sets the pins—resets those left after the first ball has been rolled, *exactly* on spot or offspot in readiness for the try for a spare. Then all pins are set for the next frame.

This ingenious machine, requires many motions coordinated, perfectly timed and kept in exact relationship. To help accomplish this, a very substantial footage of roller chains and scores of sprockets were engineered into the design—for transmitting power, for conveying, for timing and for positioning.

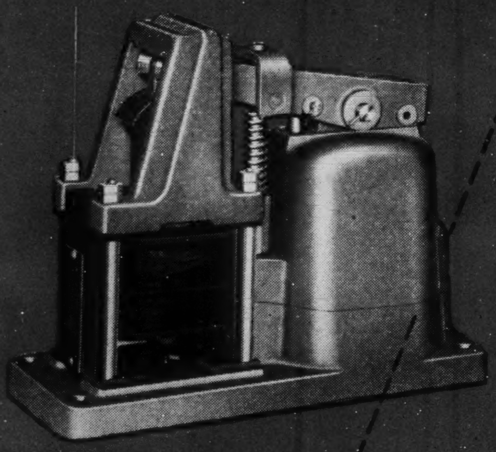
For original developments like this machine, the true uniformity of Diamond Roller Chains assures the necessary compactness, reliability, precision and accuracy of every motion, and identical operation of sets of units running in parallel. Roller chains cannot slip. They transfer power equally well and precisely with sprockets placed close together or far apart, allowing great latitude to the designer in the placement of shafts. Both sides of roller chain are alike, to run over or under sprockets.

These characteristics of Diamond Roller Chains are well known to American Machine and Foundry Co. engineers, long-time users of Diamond Chains on many other products.

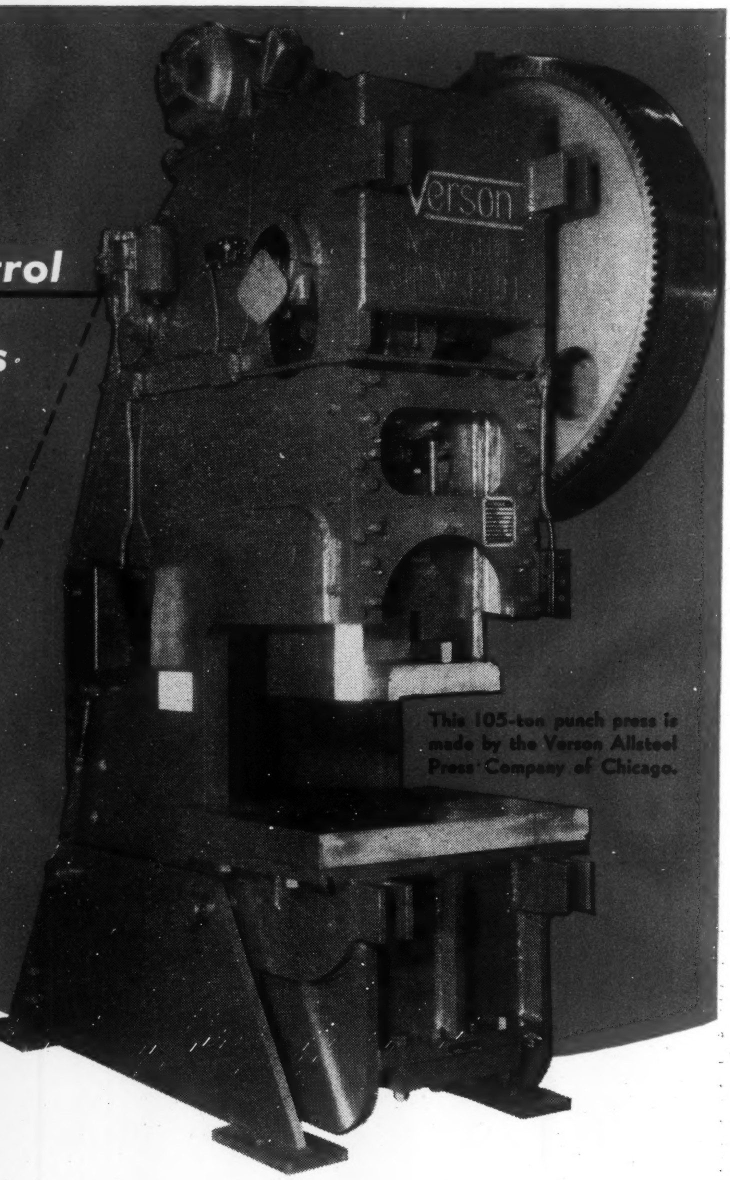
If you are planning original developments, model changes or improvements, practical recommendations by Diamond Chain engineers can help save your time. DIAMOND CHAIN COMPANY, Inc., Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana. Offices and Distributors in All Principal Cities.

DIAMOND ROLLER CHAINS

HUNT Quick-As-Wink
Valves give precision control
on 105 ton punch press



The Hunt single solenoid, spring return valve insures positive clutch and brake control on all Verson presses.



This 105-ton punch press is made by the Verson Allsteel Press Company of Chicago.

Here's another nationally known manufacturer who relies on Hunt Quick-As-Wink valves. On this Verson Allsteel punch press, a 3-way, single solenoid, spring return valve gives accurate and positive control of the operating clutch and brake. In addition, the manufacturer states, "We use Quick-As-Wink solenoid valves on all of our mechanical presses and special equipment." . . . C. B. Hunt & Son, Inc., manufactures single and double solenoid valves—hand, foot, and diaphragm operated valves for air—hand and pilot operated hydraulic types for water or oil applications. Write today for further information and for your free copy of the new Hunt Bulletin 107A.

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- ✱ Prints and develops all Bruning BW media—light, regular or card-weight BW paper prints with black or colored lines on white backgrounds—black or colored line paper prints on green tinted backgrounds—transparent paper prints—cloth or film prints—at speeds up to 30 feet per minute. Remember, unlike blue prints, BW Prints are direct line positives—not negatives.
- ✱ Designed for large volume, cut sheet production.
- ✱ Requires only one operator.
- ✱ Thirteen square feet of feedboard space for ease in handling large volume production.
- ✱ New and exclusive vacuum feed.
- ✱ Simplified controls—no gadgets.
- ✱ 75 watt per inch mercury arc light.
- ✱ Tracing and print separator automatically returns original copy to operator while sensitized media enter developer section.
- ✱ Requires no plumbing—creates no fumes to exhaust—can be installed anywhere.

YOU GET THESE SIX MAJOR ADVANTAGES with the BRUNING BW SYSTEM

1. A versatile, simple method for making black or colored line prints directly from transparent or translucent originals.
2. 45 years' experience in analyzing printmaking needs.
3. A complete direct-line printing process, including white and green tinted papers, thin, medium and card-weight papers, black, red or brown line prints. BW Transparents and BW Film (intermediate prints) to supplement original valuable tracings.
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5. A continuing service . . . because Bruning sells *everything* for the engineer and draftsman, not just BW equipment. Buying a BW machine is, therefore, not a "one time sale."
6. Continuing research and development in the customer's interest.

FIND OUT WHAT BW PRINTS CAN DO FOR *YOU* . . . MAIL THE COUPON!

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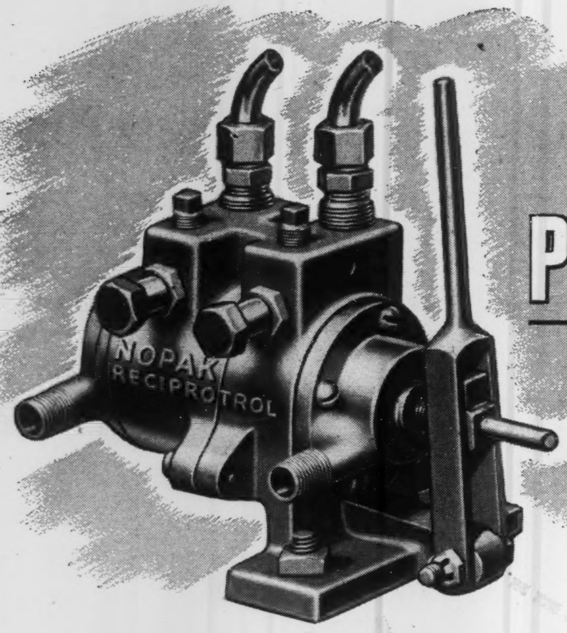


3-Way Precision CONTROL of Reciprocating Cylinder Motion!

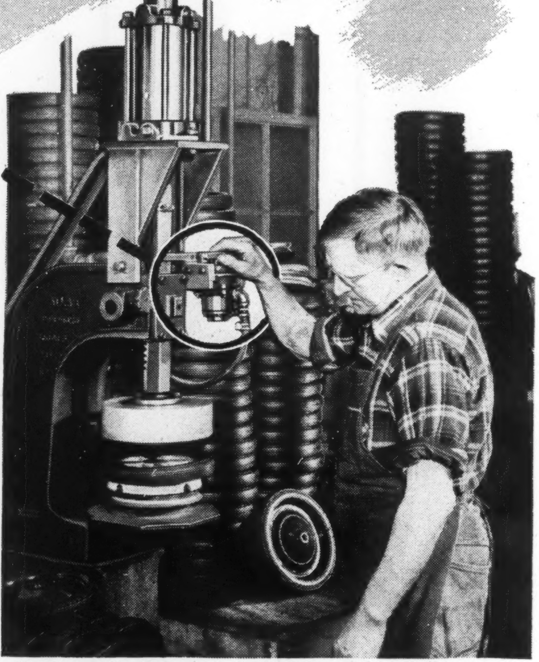
The NOPAK Reciprotrol Valve controls the reciprocating action of air and hydraulic cylinders in 3 ways:

1. It positively regulates *Stroke Speed* in *both directions,* independently.
2. It provides accurate control of Stroke Length, from "fractional" to "full".
3. It permits Precise Location of Fractional Stroke anywhere within full stroke length.

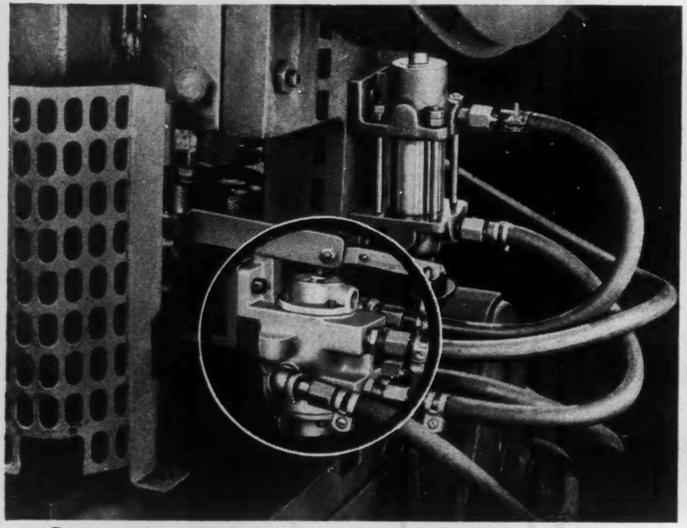
Reciprotrol provides this 3-way control for any size or make of air or hydraulic cylinder at line pressures from 50 to 300 lbs. Typical applications are pictured on this page. For further information, write —

GALLAND-HENNING MFG. CO., 2752 S. 31st St., Milwaukee 7, Wis.

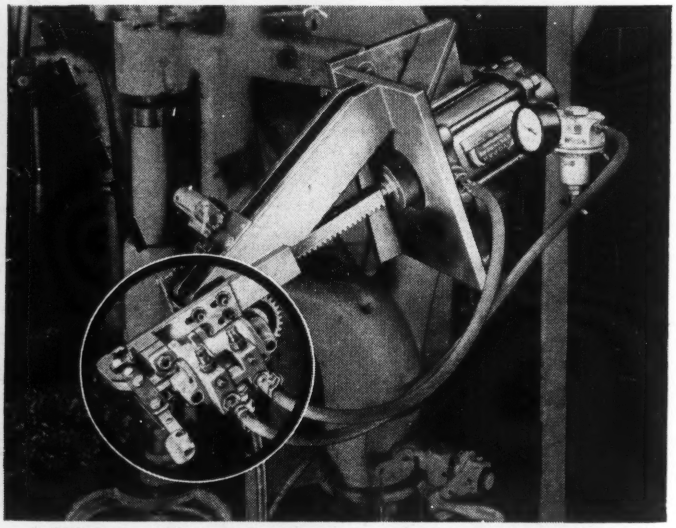
NOPAK
VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE



Reciprotrol Valve and NOPAK Cylinder convert arbor press to semi-automatic operation . . . output doubled, woman now operates press.

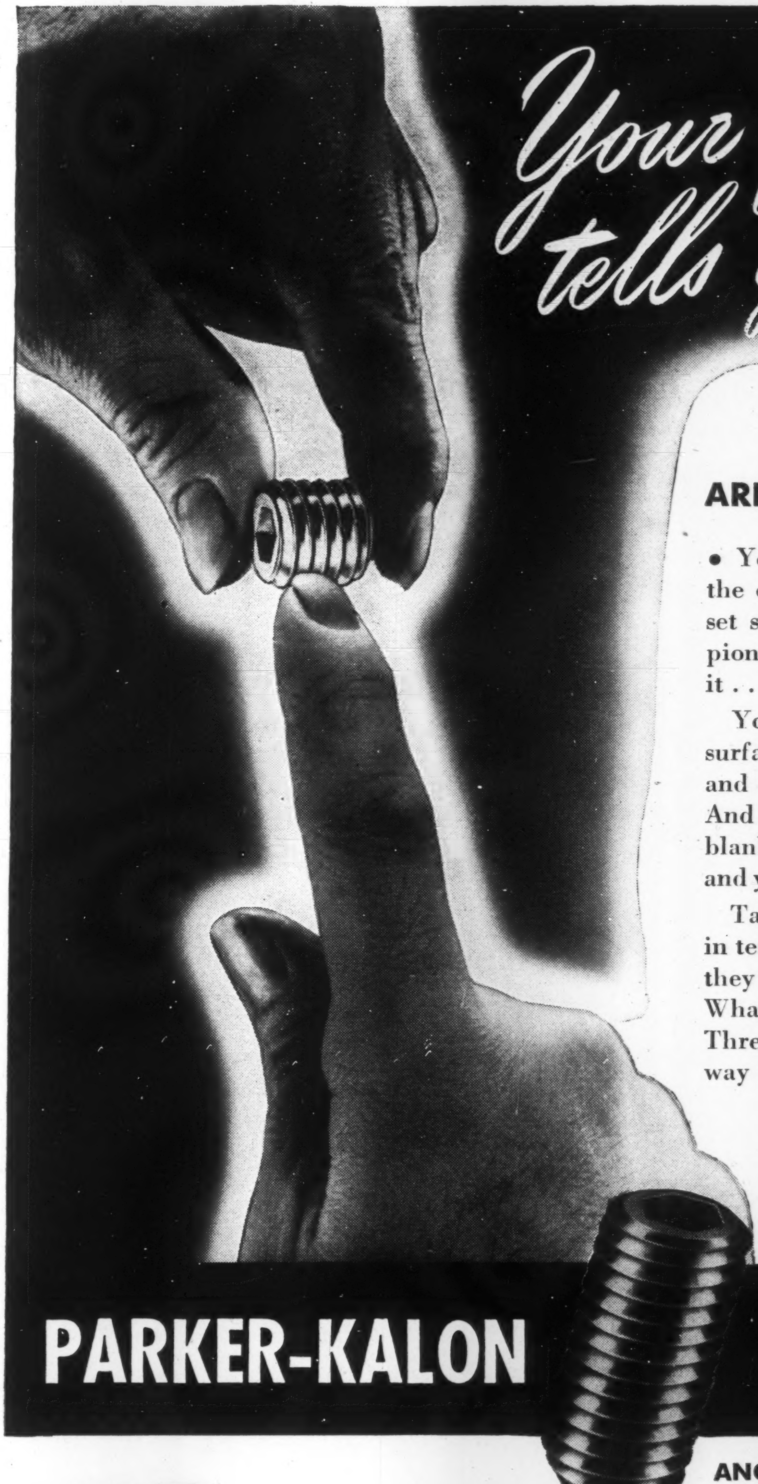


Reciprotrol regulates feed-stroke of air cylinder on metal-tube cut-off machine . . . production multiplied many times.



Old style drill presses now have automatic feed, thanks to Reciprotrol Valves and NOPAK Air Cylinders. One operator now "feeds" several machines.

Your first touch tells you why...



P-K GROUND THREAD SOCKET SET SCREWS ARE YEARS AHEAD BY EVERY TEST

- You don't need to be a skilled mechanic to detect the difference between ordinary cut thread socket set screws and *Ground Thread* Socket Set Screws pioneered by Parker-Kalon. Not only can you see it . . . but you can actually feel it!

Your first touch will tell you that its smoother surface is free from nicks, burrs, hardening cracks and other imperfections common to cut threads. And because the threads are ground on hardened blanks, hardening distortion is no longer a factor, and you can count on uniform, dependable Class 3 fit.

Talk to any good mechanic about these advantages in terms of assembly operations. He'll tell you that they assure easier starting and faster assembling. What's more, using and featuring P-K Ground Thread Socket Set Screws on any product is a good way to lift it a cut above competition.

PROMPT DELIVERIES OF SOCKET SCREWS

You can start *now* to benefit by the extra advantages of both P-K Ground Thread Socket Set Screws and Socket Head Cap Screws. With P-K's improved production facilities ample stocks of Socket Screws are available now.

PARKER-KALON *Cold-forged* SOCKET SCREWS

PARKER-KALON
presents
3
extraordinary
improvements
in
SOCKET SCREWS

SEE AND FEEL THE DIFFERENCE!

Get this unique, free sample kit that illustrates these improvements better than words. Compare! You'll agree your products will benefit—assembly-wise and sales-wise! *Write—Parker-Kalon Corp., 200 Varick Street, New York 14.*

ANOTHER P-K FIRST

★ *Size-Marked-Gear Grip** SOCKET HEAD CAP SCREWS

Quick, Sure Size Identification. The Size-Mark, clearly incised on the head, gives you size and thread pitch at a glance. Eliminates guessing or "miking". Saves time and errors at tool crib or on assembly line.

Better Control. Gear-Grip* prevents slips and fumbles even when fingers are oily. Gives highly paid hands a head start.

**U. S. Pat. No. 126,409*

★ SOLD ONLY THROUGH ACCREDITED DISTRIBUTORS ★

NATIONAL PLASTICS Exposition

To those who recall the impressiveness of SPI's first National Plastics Exposition last April, announcement of the Chicago show is headline news. In holding this exposition in Chicago the industry will present to the midwest and the nation, truly representative showing of all the new materials, machines, equipment, processes in the growing field of plastics.

It will be an *industry* show. To assure unhampered contact between exhibitors and visitors, the general public will be excluded. To all directly in the plastics industry, as well as to engineers, industrial purchasers, store buyers, designers, stylists, production managers and others whose products and functions may be enhanced by a better knowledge of plastics, SPI extends a most cordial invitation to visit the exposition. If you would like to attend the exposition, write the Society of the Plastics Industry, 295 Madison Ave., New York 17.

Concurrently SPI *is holding a national conference of its membership at The Hotel Stevens.*

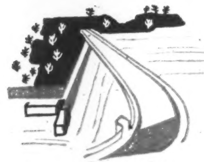
For vital information about plastics, plan now to visit SPI's great Second National Plastics Exposition!

2ND NATIONAL PLASTICS EXPOSITION

SPONSORED BY THE SOCIETY OF THE PLASTICS INDUSTRY

THE COLISEUM • CHICAGO

MAY 6 • 10 - 1947



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partners in creating

As the draftsman's pencil makes its mark, he issues orders, through a remarkable kind of shorthand, to the men who must act on his drawings. But only with special assistance can human hands shape such precise, complex orders as these. No wonder the draftsman chooses his instruments with care . . . he is, in effect, taking them into partnership!

In this sense, Keuffel & Esser Co. drafting equipment and materials have been the draftsman's partners for 80 years in creating the peaceful culture and wartime might of America, in making possible our concrete dams, steel bridges, aluminum bombers.

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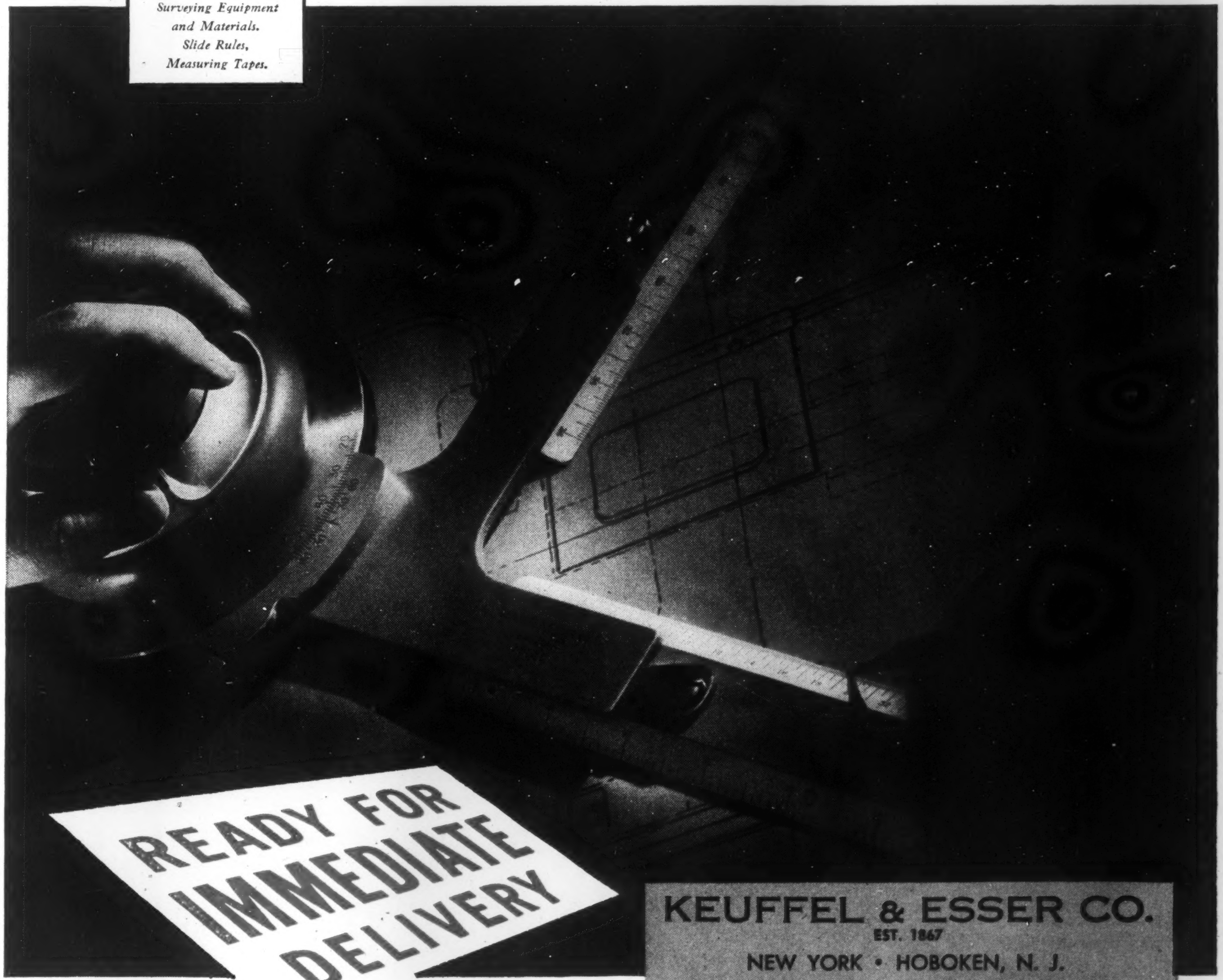

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Leather Packing Dimensional Standards

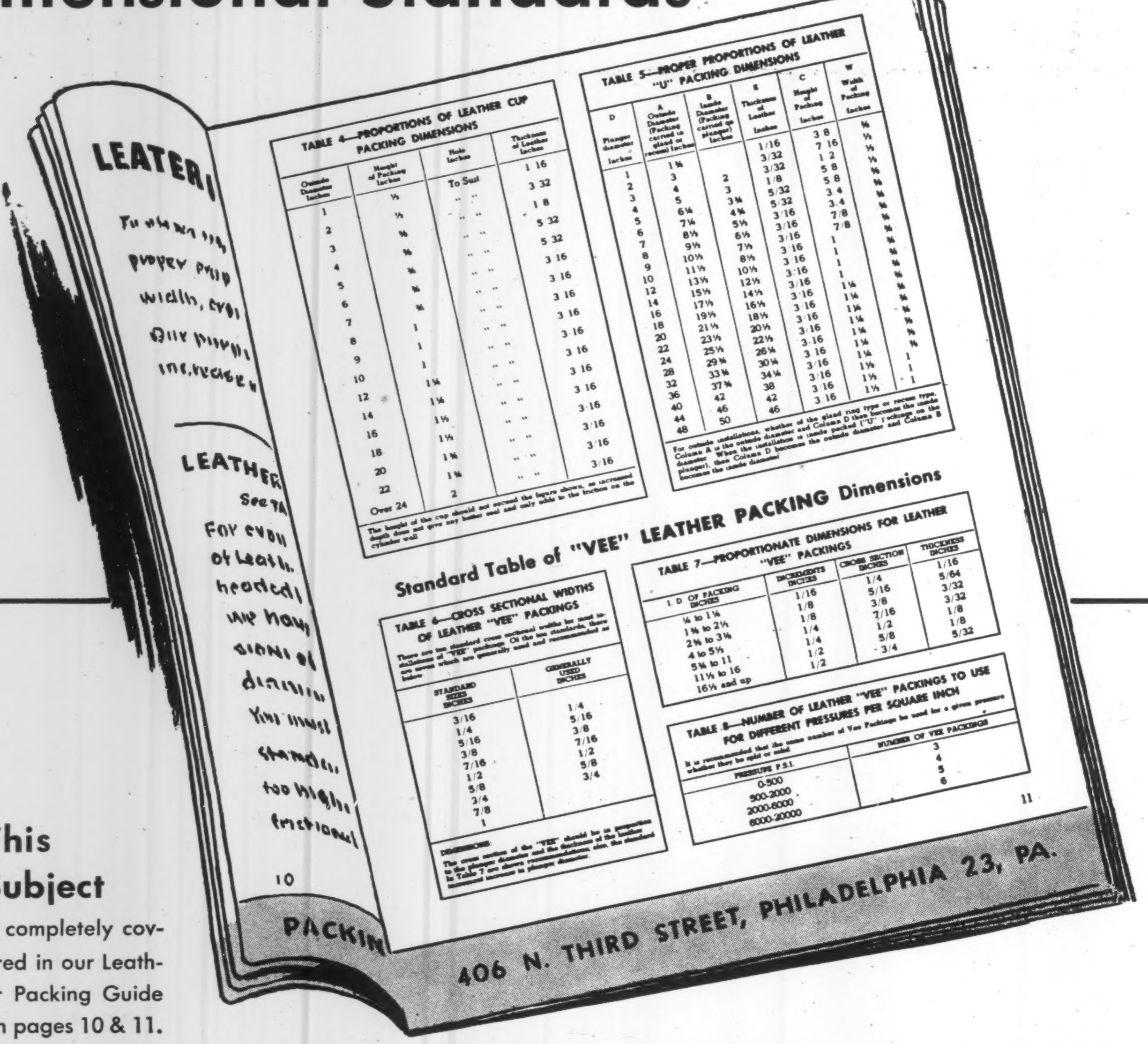
LEATER
LEATHER
See TA
10
PACKIN
11
406 N. THIRD STREET, PHILADELPHIA 23, PA.

TABLE 4—PROPORTIONS OF LEATHER CUP PACKING DIMENSIONS

Outside Diameter Inches	Height of Packing Inches	Hole Inches	Thickness of Leather Inches
1	½	To Suit	1/16
2	½	" "	3/32
3	⅝	" "	1/8
4	⅝	" "	5/32
5	⅝	" "	5/32
6	⅝	" "	3/16
7	⅝	" "	3/16
8	1	" "	3/16
9	1	" "	3/16
10	1	" "	3/16
12	1⅛	" "	3/16
14	1¼	" "	3/16
16	1½	" "	3/16
18	1½	" "	3/16
20	1⅝	" "	3/16
22	1¾	" "	3/16
Over 24	2	" "	3/16

The height of the cup should not exceed the figure shown, as increased depth does not give any better seal and only adds to the friction on the cylinder wall

TABLE 5—PROPER PROPORTIONS OF LEATHER "U" PACKING DIMENSIONS

D Plunger diameter Inches	A Outside Diameter (Packing carried in gland or recess) Inches	B Inside Diameter (Packing carried on plunger) Inches	E Thickness of Leather Inches	C Height of Packing Inches	W Width of Packing Inches
1	1¾		1/16	3/8	⅜
2	3		3/32	7/16	½
3	4	2	3/32	1/2	½
4	5	3	1/8	5/8	½
5	6¼	3¾	5/32	5/8	⅝
6	7¼	4¾	5/32	3/4	⅝
7	8½	5½	3/16	3/4	⅝
8	9½	6½	3/16	7/8	⅝
9	10½	7½	3/16	7/8	⅝
10	11½	8½	3/16	1	⅝
12	13½	10½	3/16	1	⅝
14	15½	12½	3/16	1	⅝
16	17½	14½	3/16	1	⅝
18	19½	16½	3/16	1⅛	⅝
20	21½	18½	3/16	1⅛	⅝
22	23½	20½	3/16	1⅛	⅝
24	25½	22½	3/16	1⅛	⅝
28	29¾	26¼	3/16	1⅛	¾
32	33¾	30¼	3/16	1⅛	¾
36	37¾	34¼	3/16	1¼	¾
40	42	38	3/16	1½	1
44	46	42	3/16	1½	1
48	50	46	3/16	1½	1

For outside installations, whether of the gland ring type or recess type, Column A is the outside diameter and Column D then becomes the inside diameter. When the installation is inside packed ("U" Packings on the plunger), then Column D becomes the outside diameter and Column B becomes the inside diameter

Standard Table of "VEE" LEATHER PACKING Dimensions

TABLE 6—CROSS SECTIONAL WIDTHS OF LEATHER "VEE" PACKINGS

There are ten standard cross sectional widths for most installations of "VEE" packings. Of the ten standards, there are seven which are generally used and recommended as below

STANDARD SIZES INCHES	GENERALLY USED INCHES
3/16	1/4
1/4	5/16
5/16	3/8
3/8	7/16
7/16	1/2
1/2	5/8
5/8	3/4
3/4	
7/8	
1	

DIMENSIONS:
The cross section of the "VEE" should be in proportion to the plunger diameter and the thickness of the leather. In Table 7 are shown recommendations; also, the standard incremental increase in plunger diameter.

TABLE 7—PROPORTIONATE DIMENSIONS FOR LEATHER "VEE" PACKINGS

I. D. OF PACKING INCHES	INCREMENTS INCHES	CROSS SECTION INCHES	THICKNESS INCHES
¼ to 1¼	1/16	1/4	1/16
1⅜ to 2½	1/8	5/16	5/64
2⅝ to 3⅞	1/8	3/8	3/32
4 to 5½	1/4	7/16	3/32
5¾ to 11	1/4	1/2	1/8
11½ to 16	1/2	5/8	1/8
16½ and up	1/2	3/4	5/32

TABLE 8—NUMBER OF LEATHER "VEE" PACKINGS TO USE FOR DIFFERENT PRESSURES PER SQUARE INCH

It is recommended that the same number of Vee Packings be used for a given pressure whether they be split or solid.

PRESSURE P.S.I.	NUMBER OF VEE PACKINGS
0-500	3
500-2000	4
2000-6000	5
6000-20000	6

This Subject

is completely covered in our Leather Packing Guide on pages 10 & 11.

Too often Leather Packing assemblies are designed without due consideration of the proper proportions of the dimensions, such as the outside and inside diameters, height, width, cross section, etc. The life of the packing is seriously affected if this is ignored. We will gladly send you a copy of the Packing Guide and are certain its wealth of information will prove interesting and valuable.

ALEXANDER PHILADELPHIA

FOUNDED 1867

ALEXANDER BROTHERS

406 N. Third St., Philadelphia 23, Pa.

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NAME PLATE PROBLEMS?

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DECAL NAMEPLATES

Billions of Meyercord Decals are in use throughout the world. They provide a colorful, highly legible, permanent and easy method of applying any product identification, operating instructions, patent data, lubrication guides, and wiring diagrams. They save time, labor, and materials.

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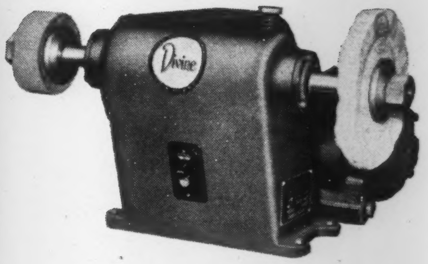
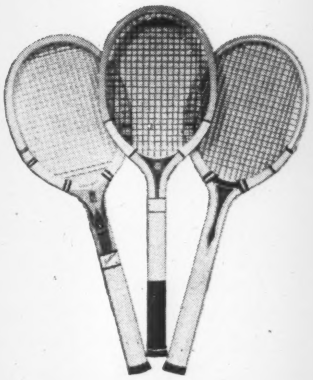
Meyercord Decal nameplates are vibration-proof, eliminate protruding edges and sharp corners, require no screws or rivets for application. Meyercord Decals are durable, washable, and can be produced in any size, colors or design. Popular water methods permit fast application.



Easy-to-use solvents or cements are specified when required. Meyercord research has developed Decals resistant to acid, petroleum products, alkali, alcohol, abrasion, temperature extremes and moisture. Can be used on rough, smooth or crinkled surfaces, flat, concave or convex.



Over fifty years of actual use has demonstrated that genuine Meyercord Decals retain their color and legibility for years without cracking or peeling. There is no commercial surface known for which Meyercord engineers cannot design a Decal for complete and perfect surface adhesion.

Meyercord Decals offer a new efficiency in product identification. Years of experience in setting up high-speed production lines for the application of Decal nameplates have developed many new and different techniques, which are now available to Meyercord customers.

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Resistant to High Pressure
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Favorable Appearance
Great Strength + Lightweight
right down the line with the qualities you want in the sizes that you need

Trentweld STAINLESS STEEL TUBING

IN your continuing effort to improve operating performance, you'll want to keep in mind the inherent advantages that Trentweld tubing offers in making machines better—more lasting—and more useful.

For example, this thin-walled or thick-walled tubing is specifically engineered to the functional character of the job it is intended for. Made by a singular automatic method of rolling and welding, this new, advanced tubing, in thin-walled or thick-walled form, is unusually uniform in composition and structure. Pickling and annealing operations are precisely controlled and adjusted to the end application of the tubing. The net result is a fine-grained metal—stainless steel or Inconel—so homogeneous, so completely free from inclusions, so especially treated for severe industrial requirements, that it has far more than an ordinary capacity for service. Any range of finish, interior or exterior, can be applied—a factor all to the good where surface appearance is important.

For these reasons and many more, Trentweld tube, in diameters from 1/8" to 24", is being used today by many top-ranking American manufacturers. Feel free to call on Trentweld engineers—as others have—to put a shoulder to the wheel on any application you have in mind. Draw on their wide experience without obligation. Address—Department 21 or write for the Trentweld Data Bulletin.

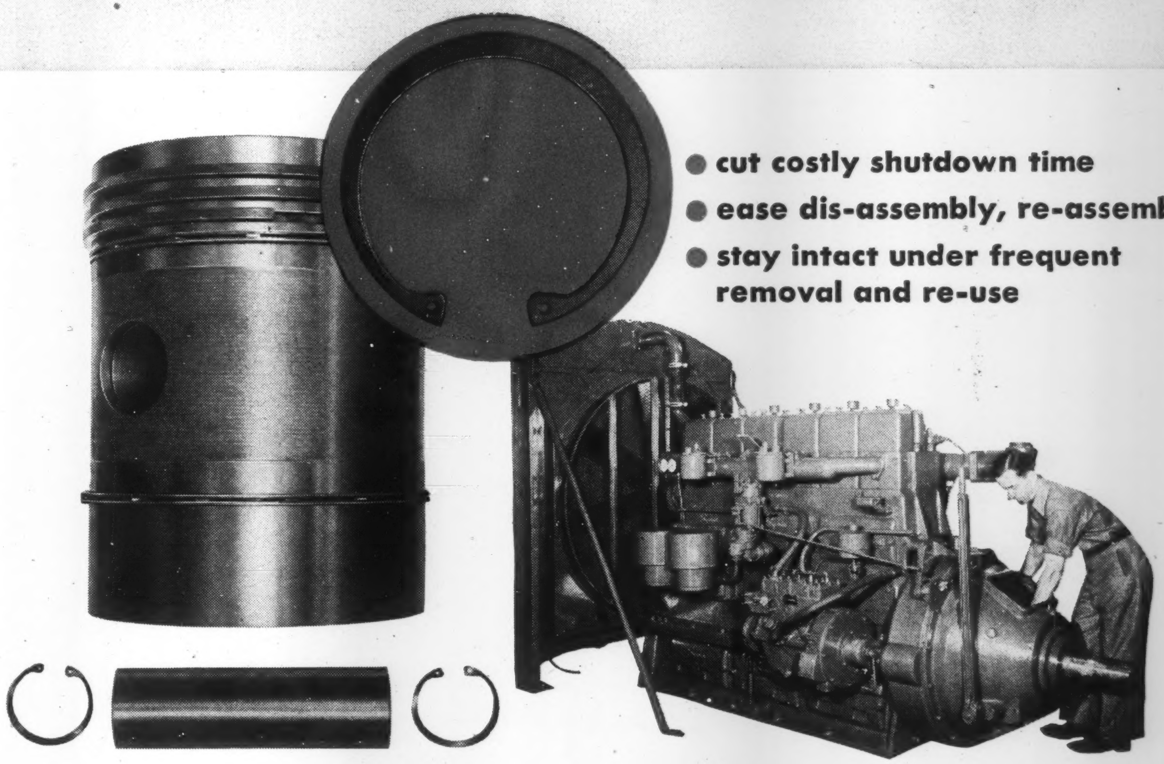
TRENTWELD STAINLESS STEEL TUBES

Sales Office—664 N. Michigan Avenue, Chicago 11, Illinois

TRENT TUBE MFG. CO.

Mill at East Troy, Wisconsin

TRUARC rings lock piston pins securely for drilling engine on 24-hour service



- cut costly shutdown time
- ease dis-assembly, re-assembly
- stay intact under frequent removal and re-use

After changing to Waldes Truarc Retaining Rings for piston pin retainers in their powerful new Superior 6G-510 oil-field drilling engine, the Superior Engine Division of The National Supply Company finds field maintenance greatly simplified.

Truarc Rings can be easily removed and replaced in a few seconds. They retain both concentricity and flexibility without regard to the number of times they are handled. Other piston pin retainers take a permanent set, delay field repairs, pile up costs.

On rocker arms and pumps, on crankshafts and plungers, on a wide variety of applications, Truarc Rings do a better job of holding moving parts together. Designers, production and maintenance men in many industries find Truarc cuts costs sharply wherever used. Its never-failing grip is a superior solution to fastening problems. Its patented design assures constant circularity under all conditions. Send us your drawings: Waldes Truarc engineers will be glad to show how Truarc can help you.

WALDES

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RETAINING RINGS

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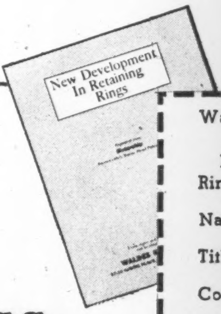

New Development In Retaining Rings

- *Send for new Truarc booklet, "New Development In Retaining Rings"*

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Please send booklet, "New Development In Retaining Rings" to:

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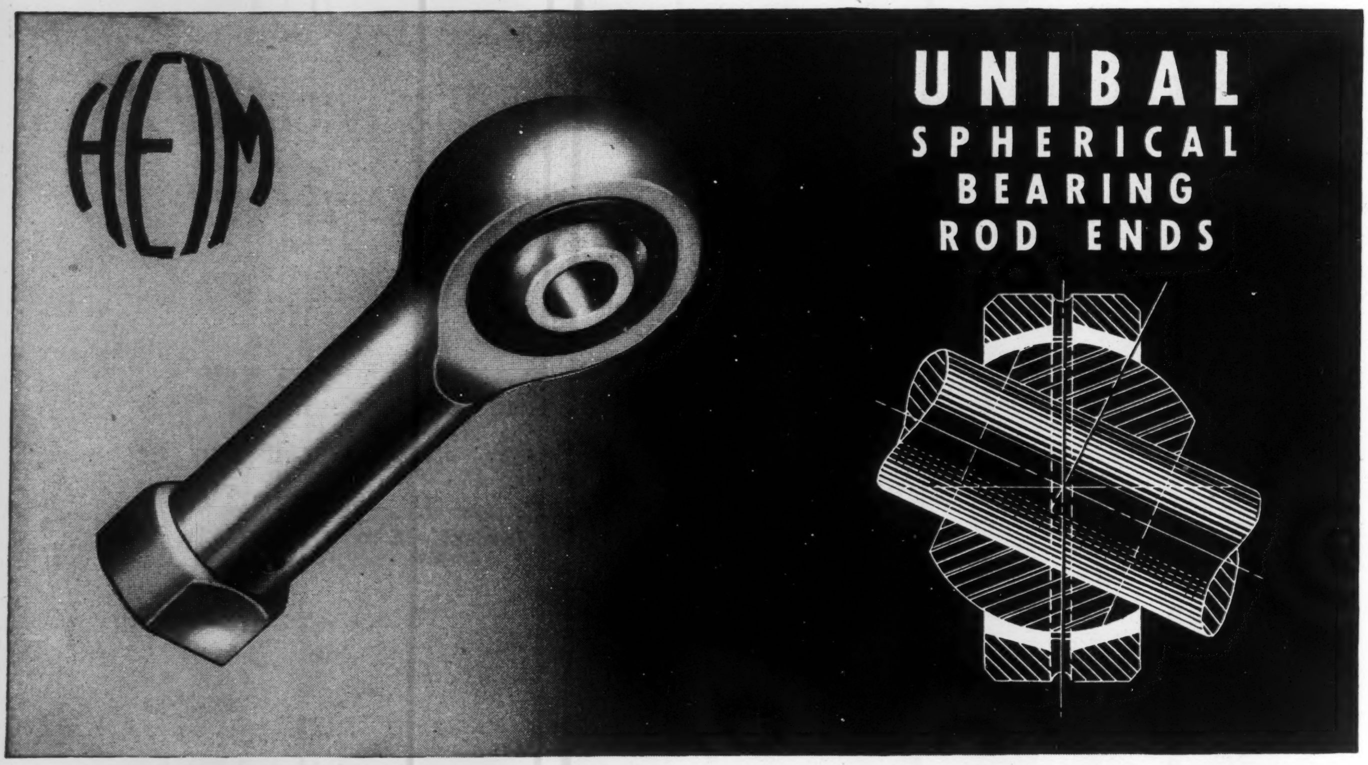
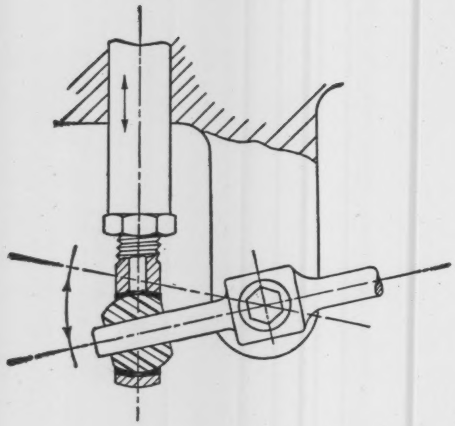


UNIBAL SPHERICAL BEARING ROD ENDS

The **HEIM** *Unibal Bearing and Spherical Bearing Rod End Corrects Misalignment All Ways*

Heim Unibal Spherical Bearings and Rod Ends are built to carry heavy loads. There is only one ball with large contact or surface supporting area. Because of this large area, they are not subject to false brinelling. The ball is made from SAE 52100 steel hardened and ground for maximum strength and long wear.

There are myriad applications for this simple but highly efficient bearing or rod end in your products. We illustrate a very simple one.



Present your problem to our Engineering Department. Send us blue prints of your present rod end or bearing construction, and we will help you in improving it and, at the same time, reduce your cost.

UNIBAL ROD ENDS

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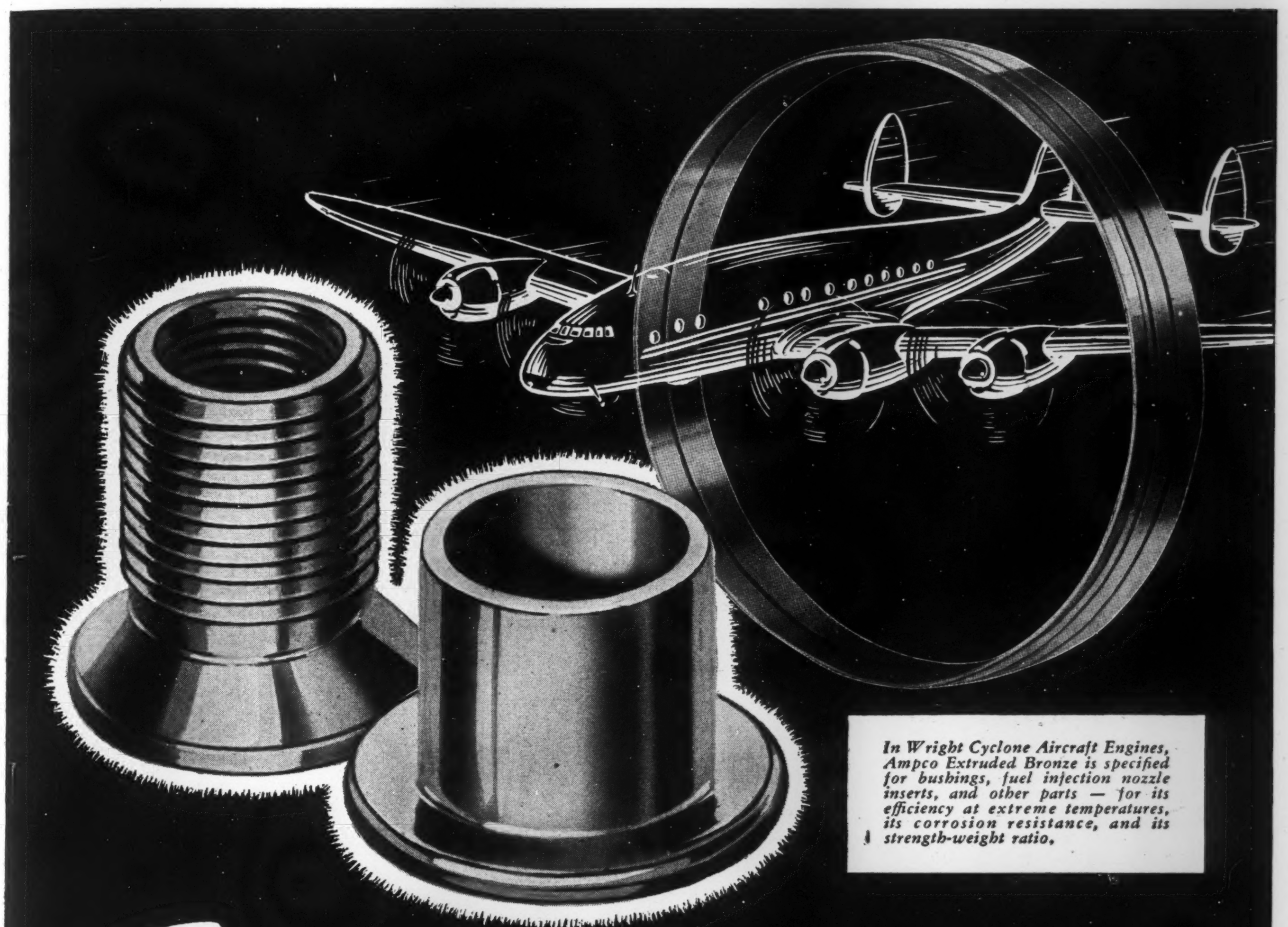

In Wright Cyclone Aircraft Engines, Ampco Extruded Bronze is specified for bushings, fuel injection nozzle inserts, and other parts — for its efficiency at extreme temperatures, its corrosion resistance, and its strength-weight ratio.

Flyin' high — and lasting longer because they're Ampco extruded bronze

. . . wear-resistant aircraft parts cost less when machined from Ampco extruded stock

Exceptionally high strength-to-weight ratio is an indispensable asset for aircraft parts. This quality is one of seven outstanding performance advantages of Ampco aluminum bronzes — advantages which give *better* and *longer* service for vital parts subject to wear in any application.

Extra economies are afforded when you can use Ampco extruded bronze rods. Extruded stock provides sizes close to most requirements—reducing waste and machining time; the smooth finish and compact structure cuts down rejects caused by physical flaws.

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Write for Bulletin 64A.

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Milwaukee 4, Wisconsin
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Resistance to — Corrosion • Compression • Impact • Fatigue • Wear — Excellent bearing qualities • Efficiency in extreme temperatures.

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The Metal without an Equal

AD-28

Q-Which brush gives the Right Contact Drop?
A- See Speer!
SPEER CARBON PRODUCTS

The m… fore carry… more than the … In general, the … low voltage eq… drop contacts…

It is customary … deemed important … physical or electrical …

This is the ohmic resistanc… inch and a length of one inch.
The total resistance of a brush may be calc… as follows;

Let K = specific resistance i…
L = length of brush in inche…
W = width of brush in inches
T = thickness of brush in inches
R = total resistance of the brush, in ohms

Then $R = \frac{K \times L}{W \times T}$

Contact Drop

This is the voltage drop between the face of the brush and the commutator or ring. Carbon is used for brushes instead of other materials, primarily because of its high contact drop. It is a notable fact that the contact drop between carbon and copper is considerably higher than that between other common conducting materials and copper, than that between two pieces of copper or that between two pieces of carbon. This high contact drop enables carbon brushes to reduce the short circuiting currents in the armature and to commutate far better than would any other known material.

Contact drop is influenced by many factors outside the brush and cannot be measured

6

MORE ANSWERS IN THIS BOOK. GET IT!

This catalog *SPEER CARBON PRODUCTS* gives detailed information on brush characteristics, includes Speer Brush Data Sheets. It answers your questions on brush selection, helps you find the right brush for your motors or generators.

A brush with the *right contact drop* reduces short circuiting currents in the armature. A brush with the *right contact drop* increases commutating efficiency, gets the most out of your commutating equipment!

There is a Speer brush with the right contact drop for your particular operating conditions. There is a Speer brush with the right combination of *all* the vital characteristics for your specific requirements. That's why Speer Brushes bring increased efficiency wherever they are installed!

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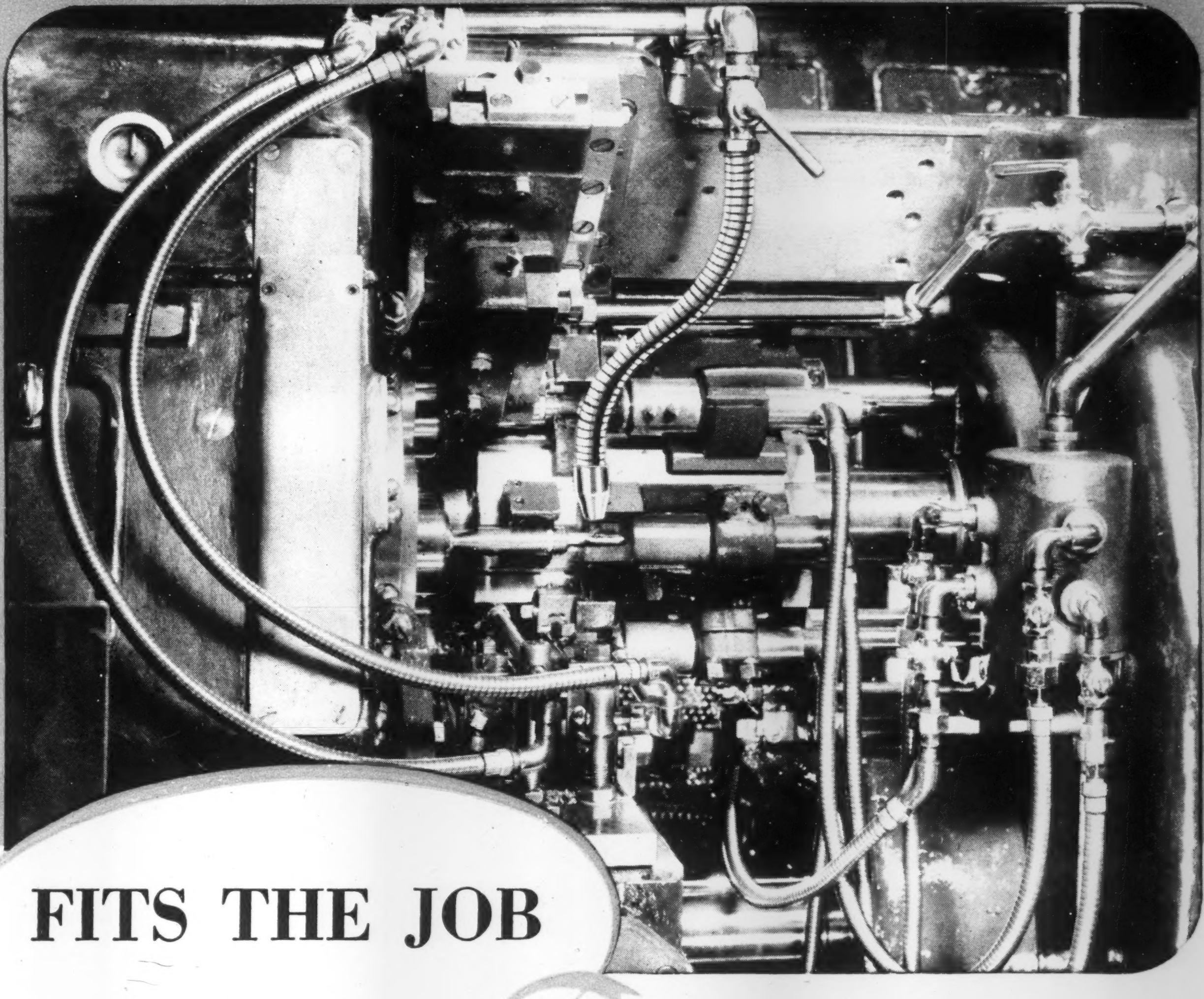

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American Oil Feed and Coolant Lines are typical of the thousands of flexible, all-metal connectors that our engineers have designed to fit particular requirements. The list includes connectors for such diverse services as moisture-proof conduit for electrical wiring; or clean, leakproof seamless flexible assemblies that absorb dangerous vibration and at the same time hold searching refrigerants under high pressures. It also includes standard steam and oil hose, constructed in several styles with varying degrees of ruggedness to fit any number of different service conditions.

If you would like suggestions on how to cut down on costs of complicated piping arrangements — how to convey heating, cooling or lubricating agents under pressure either to moving or stationary machine parts, we'll be glad to forward literature. Facts covering the complete line of American Metal Hose are yours for the asking.

We believe you can profit from learning about flexible connectors that are designed to fit the job and, better yet, to "stay fit" on the job.

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. . . ENGINEERED TO STAY ON THE JOB!

INDUSTRY . . . .

One way to help keep down rising costs of production today is to simplify piping installations — get them "right" from the start. Angular rigid piping is costly because it is time-consuming on initial installation, repeatedly high on replacement.

Admittedly flexible all-metal hose and tubing is a practical solution. Metal is sure, tight, rugged. How much more you can do with American *Flexible* Tubing which has many of the same features as rigid piping, yet because of its inherent bend-ability can be installed in a fraction of the time required for other types of piping.

The illustration shows ¾" American Seamless Flexible Bronze Tubing used on high pressure air lines to hold metallic billets during shearing operations.

TRANSPORTATION . . . .

In the air . . . where repair shops don't exist . . . connectors must perform continuously, dependably. Illustrated at right is American FLEXIBLE SHIELDING CONDUIT, first developed at the request of the Army and Navy, now universally acclaimed by airlines' operators for its proven shielding effectiveness and mechanical strength.

In other phases of transportation — on the ground — at sea — wherever there is a call for the transferring of fuel, steam, water, oil or air between moving or misaligned parts, or for use as temporary connections, American Flexible Metal Hose and Tubing is recognized as a practical money saving answer.

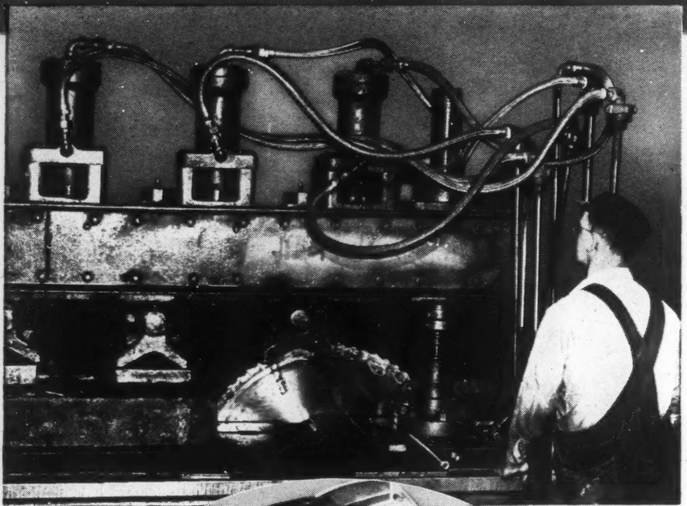
ROAD BUILDING . . . .

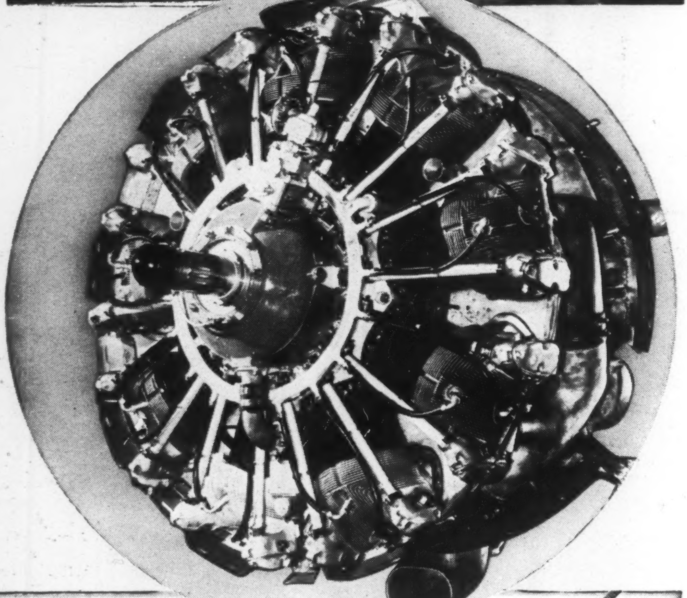
The out-of-doors is a tough proving ground, demanding tough equipment which often includes flexible hose. That's where durable American all-metal Flexible Hose shows its real merit, withstanding the necessary rough handling and dragging over rugged terrain.

For example, the chemical action of bituminous products such as tar or asphalt plays havoc with ordinary types of hose. American Flexible Metal Hose not only successfully withstands this chemical action but bears up under the quick temperature changes in the direct handling of hot tar and asphalt.

You can call for American Flexible Metal Hose with the assurance that you will have an efficient, tough conveyor that *fits the job* and *stays fit on the job.*

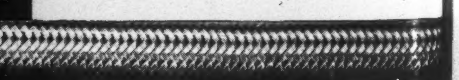
47287





American Metal Hose

THE AMERICAN BRASS COMPANY AMERICAN METAL HOSE BRANCH
General Offices: Waterbury, Conn. Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.



ANACONDA

DODGE TIMKEN

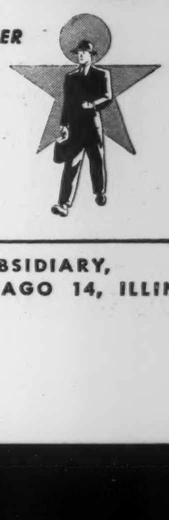
These Two Names

ON ANTI-FRICTION BEARINGS ARE YOUR ASSURANCE OF *QUALITY, DEPENDABILITY* AND *PERFORMANCE* WHICH ENABLE YOU TO CUT COSTS AND INCREASE PRODUCTION

Dodge-Timken Double Interlock Pillow Block. Dodge mounts, seals and houses the bearing assembly, delivers the pillow block fully assembled ready to lock on the shaft and run at full speed and full load. This is one of the famous Dodge 30,000 hour line, covering a wide range of industrial bearing requirements, and promptly available from Dodge distributors' stocks.

DODGE MANUFACTURING CORPORATION
Mishawaka, Indiana

DODGE
of Mishawaka, Ind.



CALL THE TRANSMISSIONEER
your local Dodge distributor, for news of latest developments in power transmission equipment. Look for his name in your classified phone book under "Power Transmission Equipment."

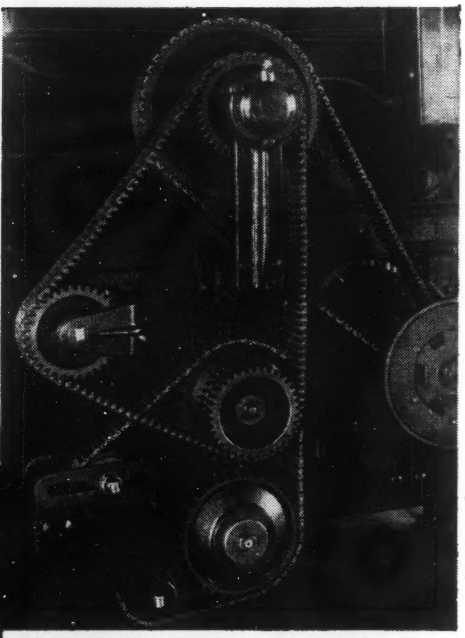
Copyright, 1947, Dodge Mfg. Corp.

NAME PLATES

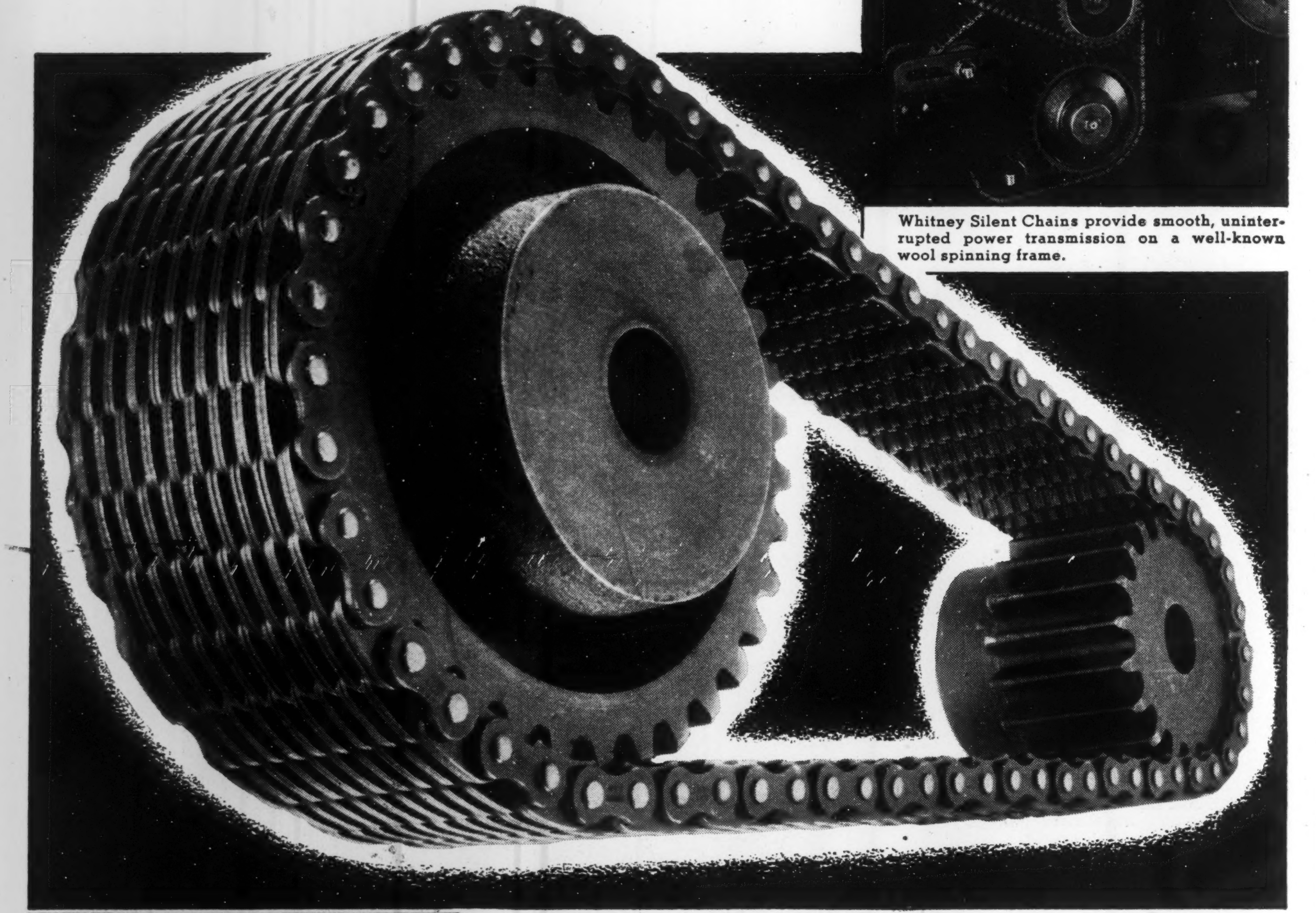
FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY,
ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS

Preferred Power Drive

IN MACHINE DESIGN



Whitney Silent Chains provide smooth, uninterrupted power transmission on a well-known wool spinning frame.



Whitney Silent Chains...

Because Whitney Silent Chain Drives are unusually flexible and adaptable to a wide variety of designs, they will simplify your power transmission problems, whether it be in textile machinery, processing equipment or machine tools.

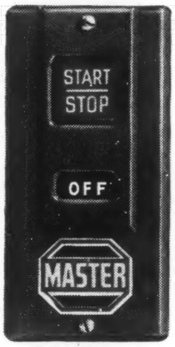
Their positive grip assures full power from driver to driven mechanisms without slippage or friction loss. They perform smoothly and efficiently, providing constant speed, thereby helping to maintain product uniformity.

Whitney Silent Chains are easy to install . . . easy to remove without disconnecting shafts or gears. They do not require frequent adjustment to maintain tension. Their hardened alloy-steel parts give maximum service with little maintenance even under the severest of operating conditions.

Teamed up with these efficient chains are accurately made Whitney Cut Tooth Sprockets . . . correctly designed to insure smooth, quiet performance and maximum operating efficiency.

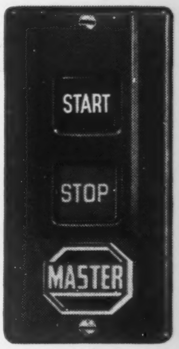
Look into Whitney Silent Chain Drives . . . the *all steel* power drives . . . for your equipment. They will simplify your design problems . . . save your money with their long trouble-free service. Write for information or engineering assistance.

THE WHITNEY CHAIN & MFG. CO., HARTFORD 2, CONN.



SINGLE OR TWIN BUTTON CONTROL STATIONS

Master's exclusive *single button control* is obtainable either integral with the starter or in a remote control station (left). Only one push button—one set of control contacts—no auxiliary contacts in starter. The visual mechanical signal gives unfailing "ON" or "OFF" indication: no bulbs to burn out or replace. . . . When multiple remote control of a single starter is required, Master furnishes conventional two-button remote stations (right).



Master Offers Both

Yes, Master gives you many more good practical advantages built into A.C. across-the-line, magnetic motor starters. For example:

All contacts are readily removable from the front. Moving contacts are double-faced for double life.

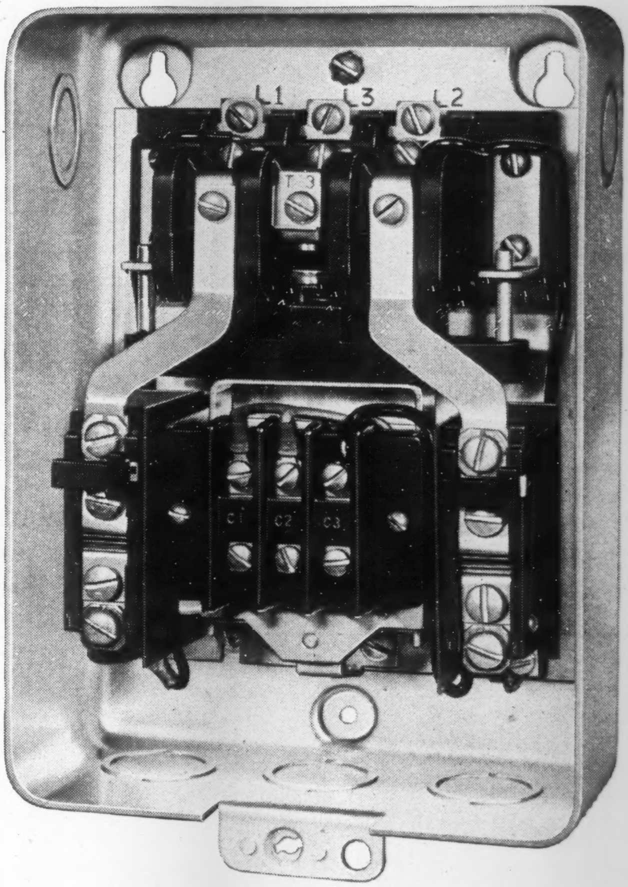
Jumpers, heavy formed straps instead of flexible wires, add rigidity to the contact assembly.

You can connect remote stations readily—without guesswork—to the plainly marked terminal board in front of the solenoid.

Heaters are accessible from the front: you can install them in next to no time.

Knockouts? Plenty. Wiring space? Ample. Styling? Modern in every detail.

One thing more: these controls bear a name long famous on motors. You can trust it, too, on motor controls. Write for bulletin 200.



THE MASTER ELECTRIC CO. **DAYTON 1, OHIO**

CALL ON B&W for...

NITRALLOY mechanical TUBING

...a short-cut to tough, hard parts

PROPERTIES

	Nitralloy No. 135 Type "G"
Carbon	.30 — .40
Manganese	.40 — .60
Silicon	.30 — Max.
Chromium	.90 — 1.40
Aluminum	.90 — 1.40
Molybdenum	.15 — .25

	Nitralloy No. 135 "Modified" (Aircraft Spec.)
Carbon	.38 — .45
Manganese	.40 — .70
Silicon	.30 — Max.
Chromium	1.40 — 1.80
Aluminum	.95 — 1.35
Molybdenum	.30 — .45

NITRALLOY seamless tubing will save you considerable time, costs and materials in machining hollow cylindrical parts in which you require great resistance to wear, seizure or abrasion along with toughness and high durability. After the Nitriding process, Nitralloy parts combine a high surface hardness (960-1140 Vickers) with a comparatively soft and resilient inner core. They do not lose their hardened case even at temperatures up to 750F.

The unique combination of properties in this tubing make it an ideal material for making scores of different tough, hard parts...from aircraft engine liners to husky wrist pins.

Two grades of Nitralloy tubing are available for mechanical uses—135(Type G) and 135(modified). Send for complete technical data on this latest addition to B&W's wide selection of Seamless and Welded Mechanical Tubing.

TA 1399M

Other B&W Products

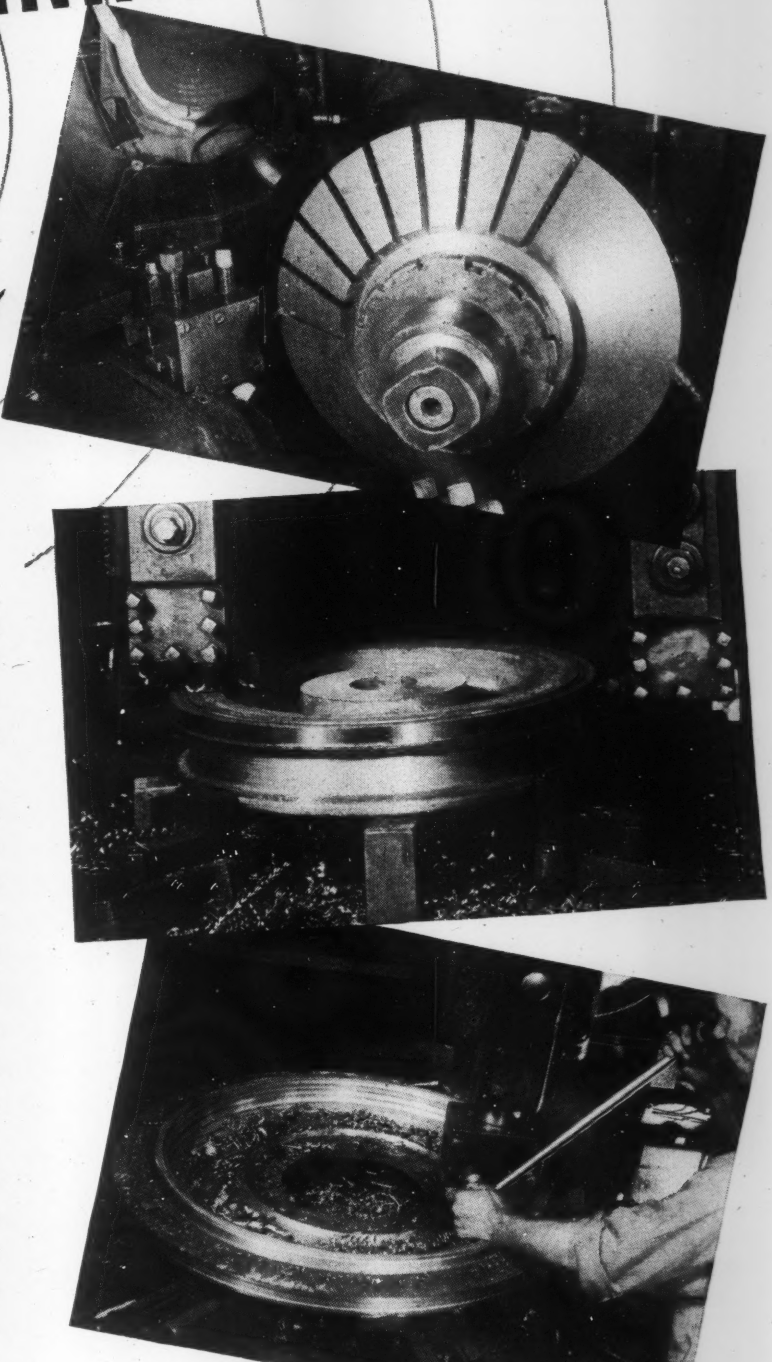
THE BABCOCK & WILCOX CO.
85 LIBERTY STREET • NEW YORK 6, N. Y.

Water-Tube Boilers, for Stationary Power Plants, for Marine Service • Water-Cooled Furnaces • Superheaters • Economizers • Air Heaters • Pulverized-Coal Equipment • Chain-Grate Stokers • Oil, Gas and Multi-fuel Burners • Refractories • Process Equipment.

BABCOCK & WILCOX
SEAMLESS & WELDED TUBES
THE BABCOCK & WILCOX TUBE COMPANY
GENERAL OFFICES: BEAVER FALLS, PA.
PLANTS: BEAVER FALLS, PA. AND ALLIANCE, OHIO.

FEWER MACHINING OPERATIONS

WITH BETHLEHEM *Circular* STEEL FORGINGS



In the customers' plants Bethlehem circular forgings are machined into finished parts. Shown here, top to bottom, are a miter gear, a crane wheel, and a tire mold in the process of manufacture.

WHY?

Because we do part of the machining job ourselves, before these forgings are ever shipped to you. All the blanks are rough-machined in our plant; it's an item that need not be included when you plan your operations.

This is an important advantage to makers of gears, crane wheels, turbine rotors, sheave wheels, tire molds, and other finished circular products. But it's by no means the only advantage. For Bethlehem blanks are manufactured by a unique process that combines the steps of upsetting, forging, and rolling; produces forgings of fine quality and uniform metal density. Due to this fine quality, thinner sections and savings in weight are often made possible.

These forgings are available in carbon or alloy steel, treated or untreated, in sizes from approximately 10 in. to 44 in. OD. If you'd like to see how nationally-known manufacturers are using them, send for illustrated Booklet 216.

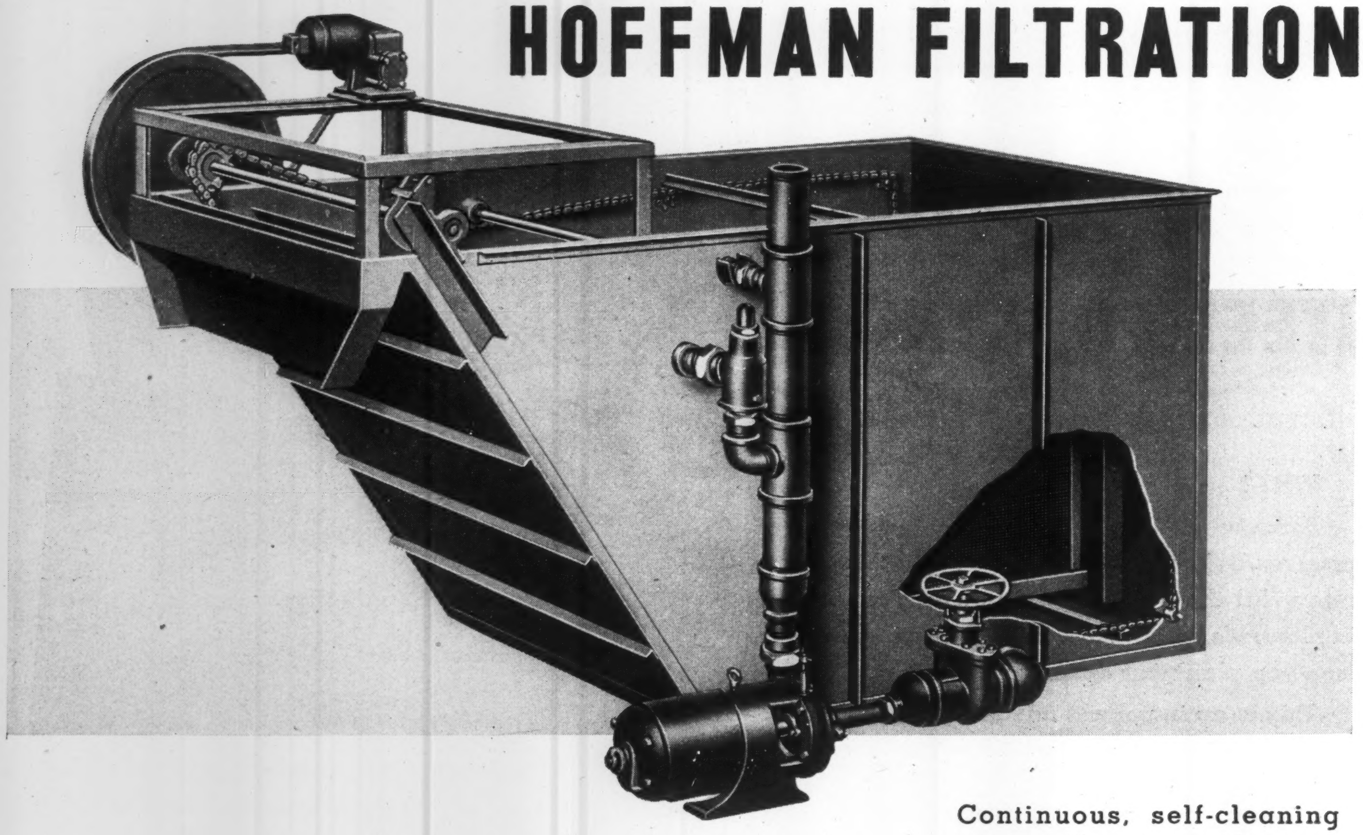
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation

★ BETHLEHEM STEEL ★

BETHLEHEM ROLLED-AND-FORGED CIRCULAR PRODUCTS

SAVE ON PRODUCTION AND MAINTENANCE COSTS WITH HOFFMAN FILTRATION



Continuous, self-cleaning vacuum filters in a wide range of sizes. Especially designed for grinding operations . . . operated with or without filter-aid powder.

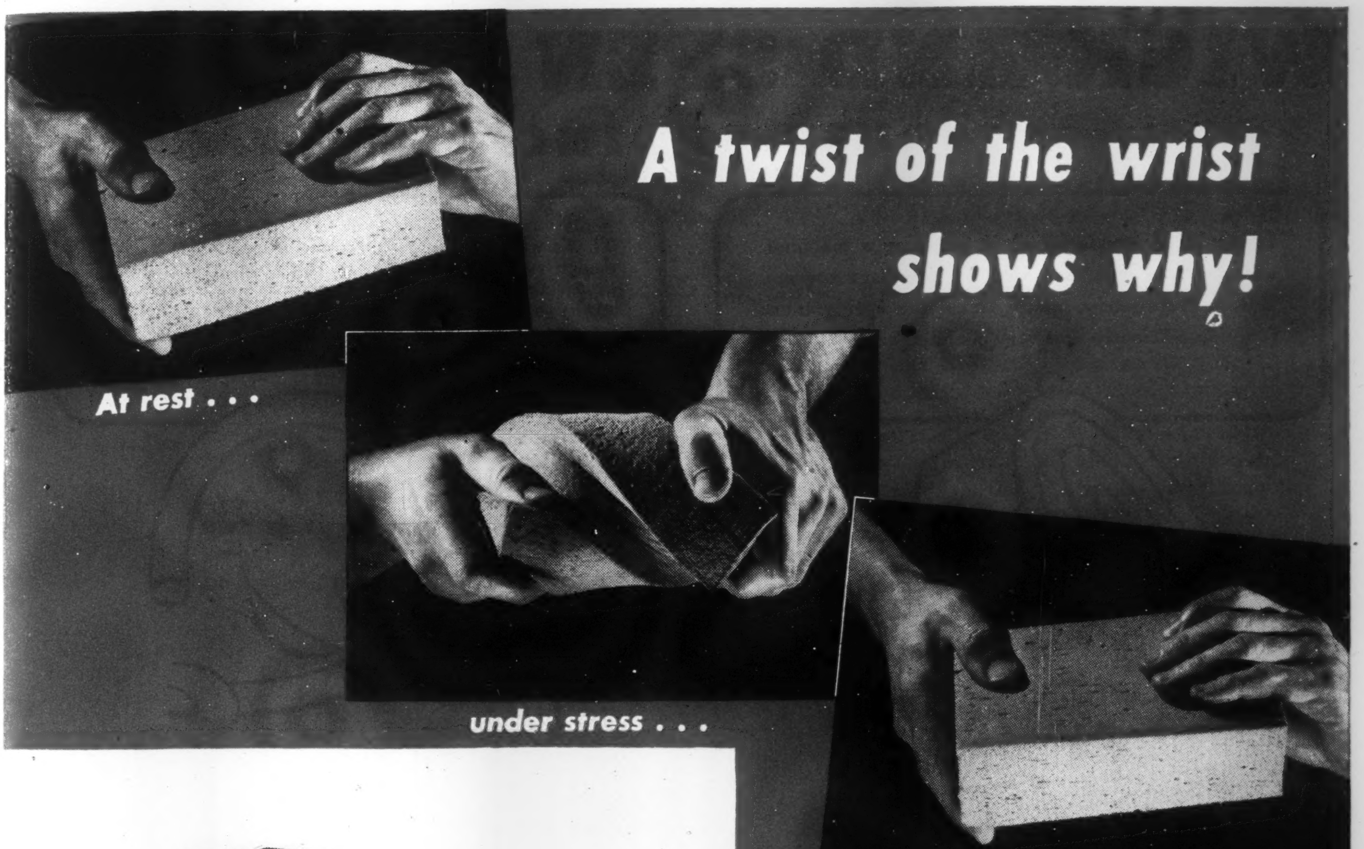
PRODUCTION costs go down when Hoffman Filtration goes into your plant. Hoffman Filtration of wash oils, machine tool coolants and other industrial oils, lengthens life of machines, cutting tools and grinding wheels.

Hoffman Filtration practically eliminates pump trouble, bearing trouble and reduces wear and clogging on all moving parts on machine tool as well as in filter operation.

Expert Hoffman filtration engineers are available to help you determine the filtration requirements for your particular operation and design special models if necessary.

Write for details today.

U.S. HOFFMAN MACHINERY CORPORATION
211 Lamson St., Syracuse, N.Y.
COOLANT FILTERS · FILTRATION ENGINEERING SERVICE

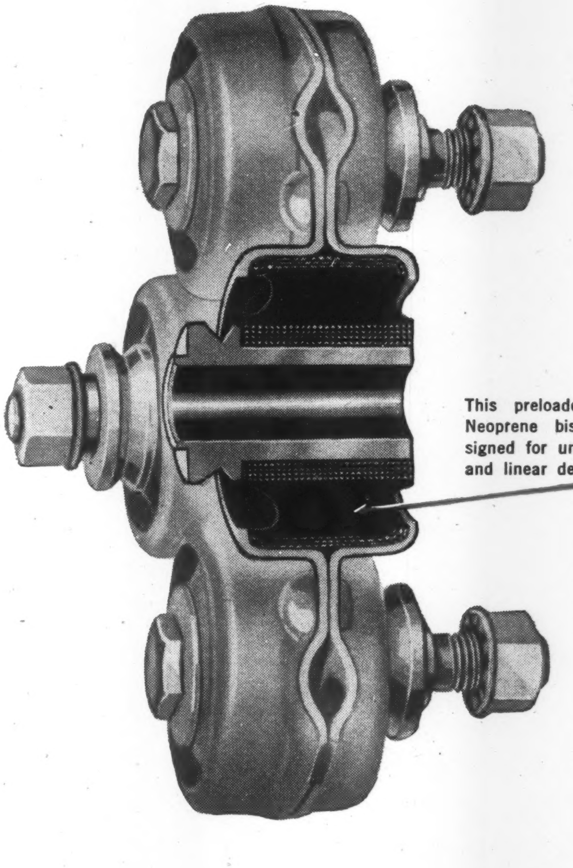


A twist of the wrist shows why!

At rest . . .

under stress . . .

and return



This preloaded, resilient Neoprene biscuit is designed for uniform stress and linear deflection.

Morflex Couplings have *LIVE* Torsional Resilience

By live, muscle-like flexing, Morse's exclusively designed Neoprene biscuit assembly shields machine installations from shock and uneven impulses. Through its torsional resilience (softness) Morflex takes the wrap-up. Misalignment stresses are minimized, resulting in longer bearing life. Address application problems to our Detroit office.

MORSE CHAIN COMPANY • Detroit 8, Mich. • Ithaca, N.Y.

MORSE *MECHANICAL POWER TRANSMISSION PRODUCTS*

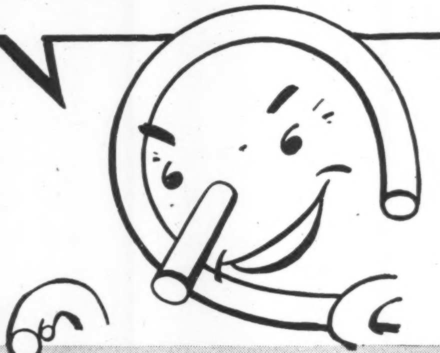
A PRODUCT OF
B-W
BORG-WARNER

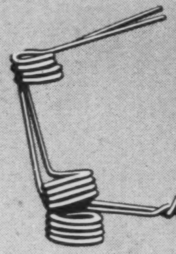
WICK AND SPEN

DISCUSS SPRING "KNOW-HOW"

It would be wonderful if, in planning a machine, enough room were provided for necessary springs. But, unfortunately, many times the spring must function efficiently in a very confined area.

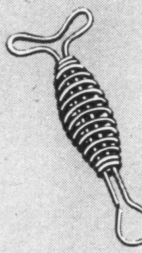
That's when know-how becomes important—for the design of a spring calls for the application of engineering principles, plus experience and judgement. Many of our spring specialists have been with us for over 25 years, during which time we have engineered over 50,000 different spring designs. Here are a few of them.





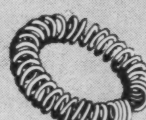
DESIGN No. 27793
BOBBIN SPRING

This torsion spring, which holds the bobbin in the shuttle of a weaving loom, is an example of the results that can be obtained with skillfully tooled winding and bending jigs. The necessity of functioning in a narrow space accounts for the odd shape of the spring.



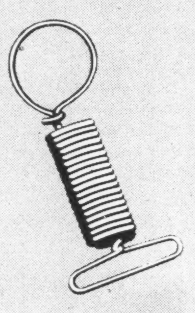
DESIGN No. 34026
HOT PAD HANDLE

In the low cost production of this wire form the spring is made independently. After the upper end of the form is shaped, the spring is slipped on and the lower loop formed on a jig.



DESIGN No. 35266
SEWING MACHINE COMPRESSION SPRING

Made of a specially processed wire, this spring is coiled in straight section and formed to circular shape. The spring must work under vibration and stand unusually severe use for a spring of this type.



DESIGN No. 29456
HARNESS SPRING

After winding of the coils, the ends of this spring are formed by means of special tools and jigs. The special ends indicate what can be done to form wire to meet the needs of an assembly.

THIS BOOK MAY SAVE YOU MONEY

Our book, "Springs and Wire Forms" gives valuable data relating to spring performance, technical information, formulae and tables needed to help in proper spring selection. Write today for your free copy. Remember too, that our engineers are at your service in designing any conceivable type of spring. We've saved time and trouble for many of our customers. We can do the same for you.

SPRINGS
AND FORMED WIRES
WICKWIRE SPENCER STEEL

WICKWIRE SPENCER

CF&I

Springs

A PRODUCT OF THE WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION
Spring Sales Office and Plant—2 New Bond St., Worcester 6, Mass.
General Office—500 Fifth Avenue, New York 18, N. Y.
Sales Offices—Boston • Buffalo • Chicago • Denver • *Pacific Coast*—The California Wire Cloth Corp., Oakland 6, Cal.

RINGS by AMERICAN WELDING

INSIDE DIAMETERS 5 INCHES TO 8 FEET

The flash weld used in the fabrication of our rings is a forged weld, made without any metal being added. For purposes of design, it has the same physical properties as the parent metal.

Welded rings are now being used for electrical motor frames, gear blanks, bearing races, clutches, flanges and boiler elements, in stainless and other heat and wear resistant materials, to mention just a few. They have stood the test by any method of comparison.

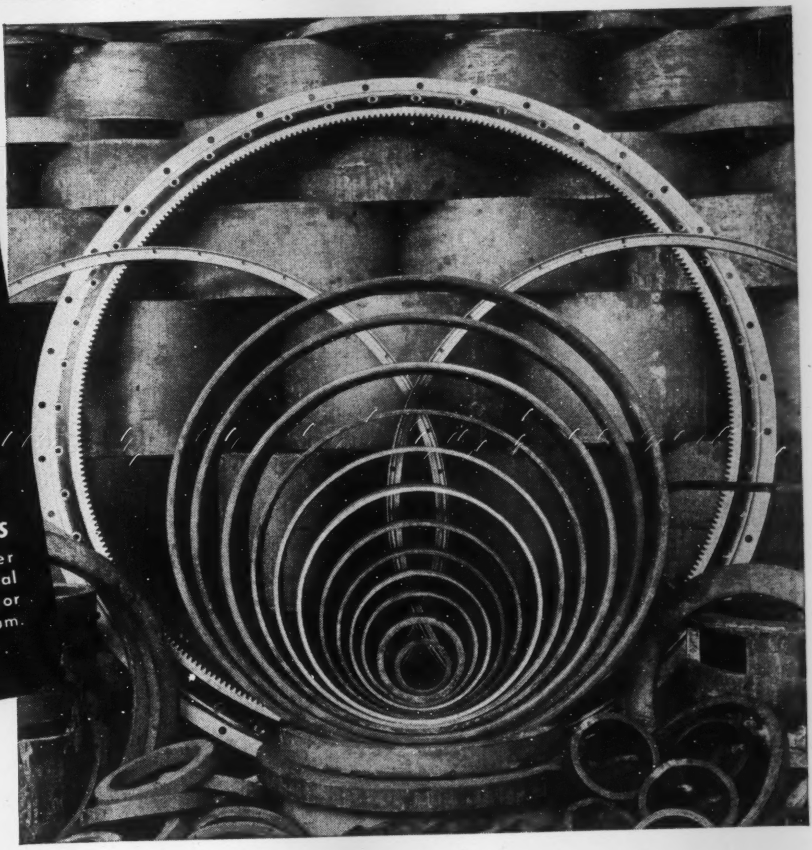
As pioneers in welded ring production, we will be glad to show you how they can be applied to your products—help you to produce better, quicker and more economically. Write for our illustrated booklet.

1. Rolled Product
Accuracy of dimension tolerances obtained in flat rolled bars or plate is reflected in finished rings.

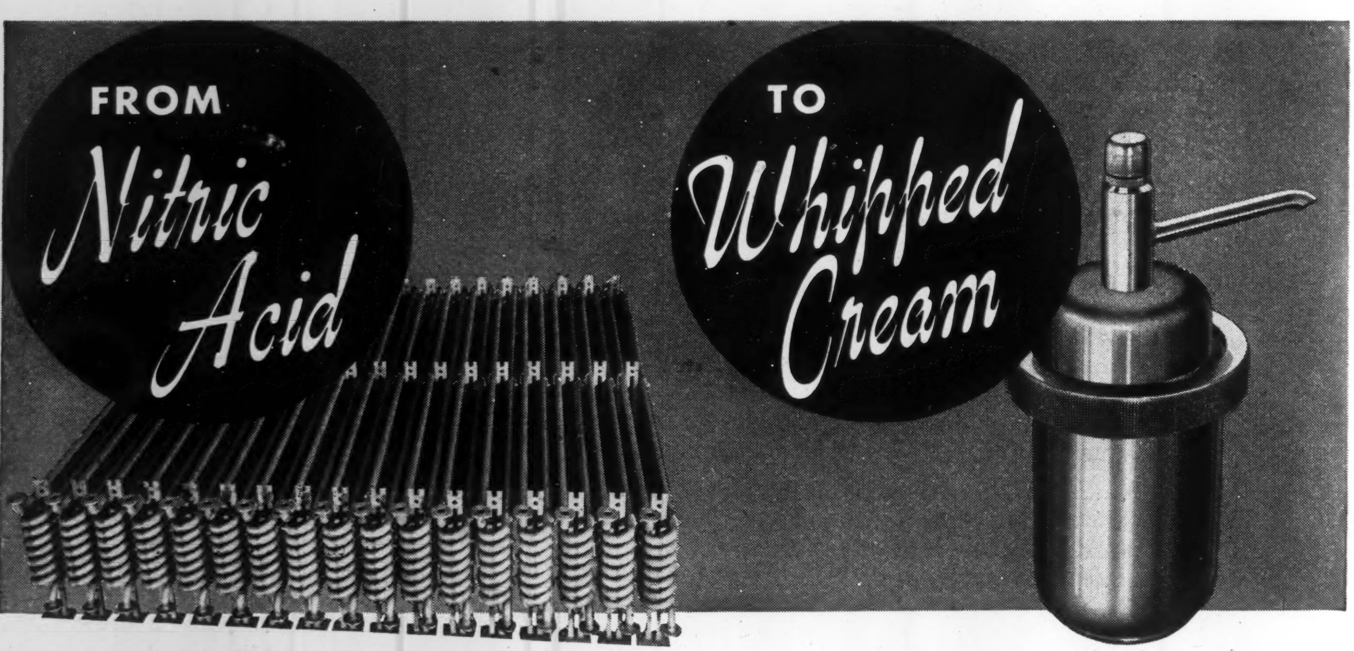
2. Uniformity of Structure
Made from flat rolled steel, American welded rings are free from blow holes and harmful inclusions.

3. Variety of Analyses
More readily obtainable in bars and plates is a wide variety of analyses which assures the opportunity of specifying the material for the job.

4. Savings of Materials
In comparison with other methods, amount of material to be removed in machining or finishing is held to a minimum.



THE AW AMERICAN WELDING & MANUFACTURING CO. · WARREN, OHIO



Nitric acid cooling coils made from 12 gauge, 3" O.D. Carpenter Stainless Tubing—Type 347. Uniform walls throughout each length help to cut fabricating costs on jobs like this.

Easy to clean and keep clean, this tubing is ideal for jobs where sanitary requirements are rigid. The Tubing in this whipped cream dispenser is ⅜" x 16 gauge.

...you can handle your design problem with *Carpenter* Stainless Tubing!

Do you need a bright, gleaming finish that will shout Sales Appeal? Or does your design have to do with heat resistance or corrosive agents in various concentrations?

On any jobs where you think Stainless Tubing may solve your problem, it will pay you to get in touch with Carpenter. For 20 years we have been working with engineers—helping them to get the most from a wide range of Carpenter Stainless Tubing analyses, sizes and shapes.

And by all means, drop us a note on your company letterhead and ask for the useful Carpenter Stainless Tubing Slide Chart. It contains useful data on Physical Properties, Velocity Constants, Mass Velocity Constants, Sizes and Surface Areas per Lineal Foot of Tube.

more than corrosion resistance

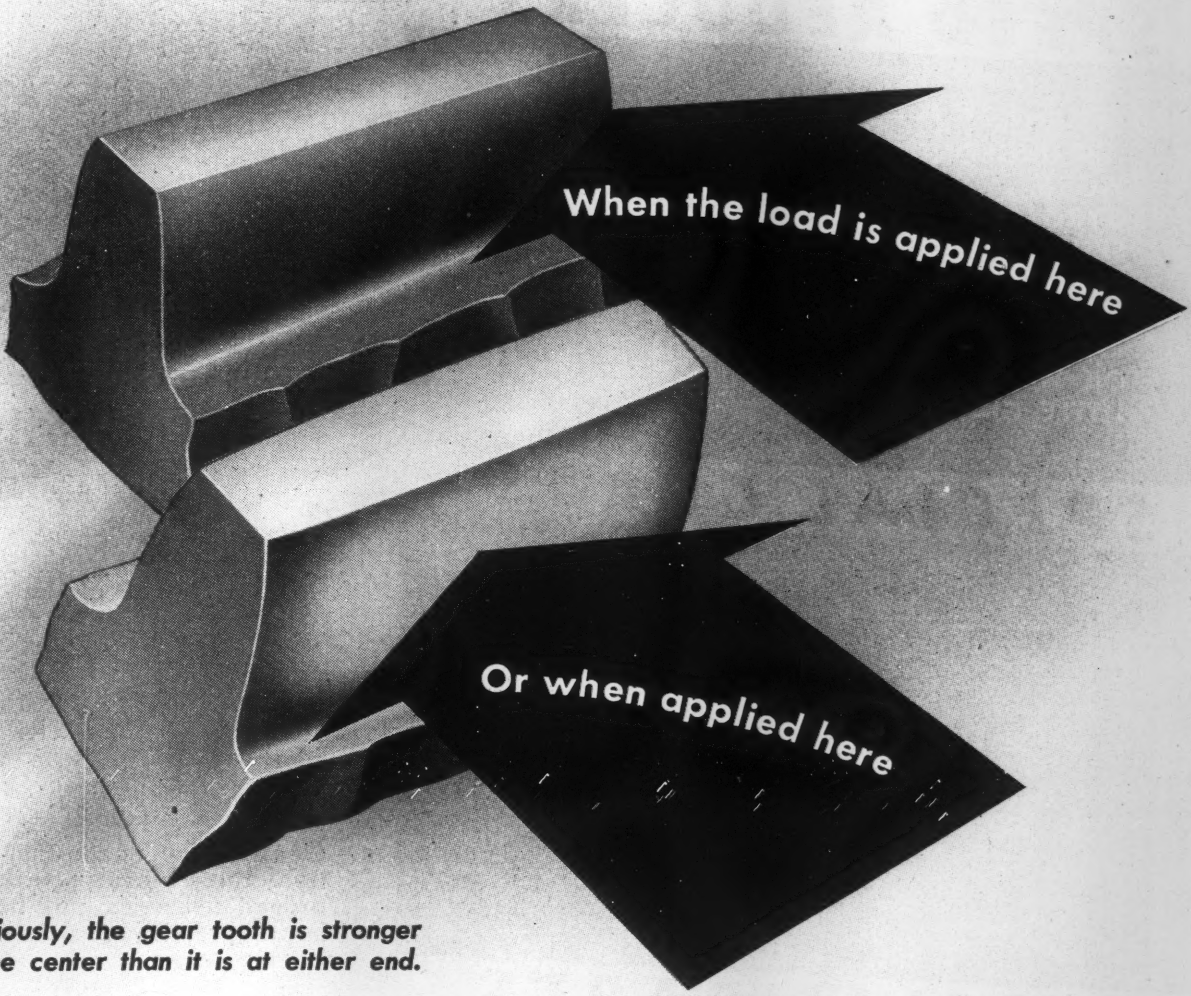
CARPENTER STAINLESS TUBING for

- Strength and Rigidity
- Weight Savings
- Corrosion Resistance
- Heat Resistance
- Accuracy
- Fabricating Savings
- Longer Service Life
- Sales Appeal

THE CARPENTER STEEL COMPANY • Welded Alloy Tube Division • Kenilworth, N. J.

Carpenter
STAINLESS TUBING

WHERE IS A CRITICALLY LOADED GEAR TOOTH MOST APT TO BREAK?


When the load is applied here
Or when applied here

Obviously, the gear tooth is stronger at the center than it is at either end.

Therefore, only when loads are confined to the central tooth section and avoided at the tooth ends is maximum tooth strength developed.

That is precisely what is accomplished when gear teeth are given the Elliptoid form. The amount of crown need be very little. From .0003″ to .0005″ per inch of tooth face is sufficient to centralize the loads and protect the gear.

Elliptoid teeth are produced on Red Ring Gear Shaving Machines for both spur and helical gears up to 36″ pitch dia.

Ask Red Ring Engineers for performance data on gears of this type.

2524

RED RING PRODUCTS

NATIONAL BROACH AND MACHINE CO.

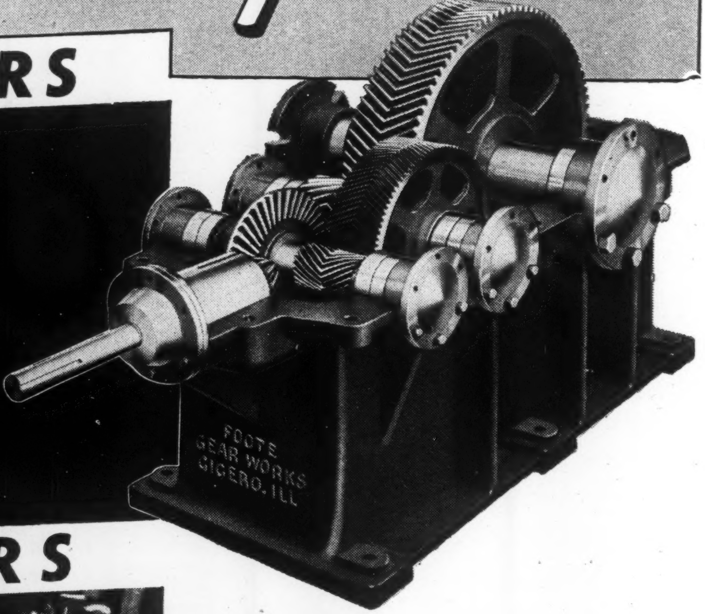
5600 ST. JEAN • DETROIT 13, MICHIGAN

SPECIALISTS ON SPUR AND HELICAL INVOLUTE GEAR PRACTICE • ORIGINATORS OF ROTARY SHAVING AND ELLIPTOID TOOTH FORMS

Brad Foote Gears

FOR

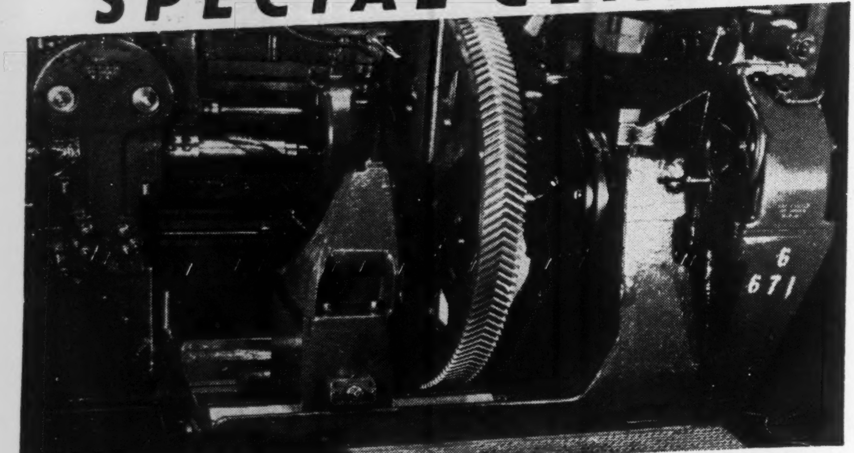
SPEED REDUCERS



RATIOS

HERRINGBONE	2:1 to 295:1
WORM	3⅝:1 to 60:1
GYRO	16:1 to 30,000:1
SPUR	2:1 to 40:1
VERTICAL HELICAL	2:1 to 80:1
SPIRAL BEVEL	1:1 to 5:1
PLANETARY	4:1 to 400:1
OIL WELL UNITS	12:1
LITTLE GIANT	28:1

SPECIAL GEARS

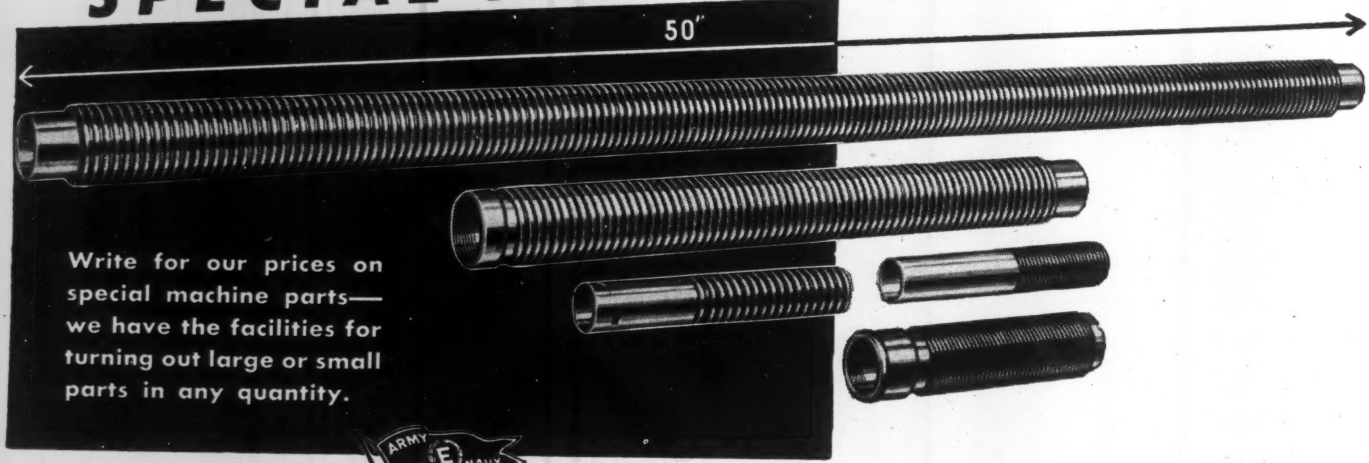


Brad Foote diversified and extensive equipment permit the manufacture of all types of special precision cut gears.

Bevels, Straight, Spiral or Mitre, Spur, Herringbone, Helical are made at Brad Foote in any practical size from any practical material.

Gears are under constant inspection and close control and prompt deliveries may be made in any proportion.

SPECIAL PARTS



Write for our prices on special machine parts—we have the facilities for turning out large or small parts in any quantity.

BRAD FOOTE GEAR WORKS

1309 S. CICERO AVENUE
CICERO, ILLINOIS, DEPT. A

New tool-holder has Neoprene Insert

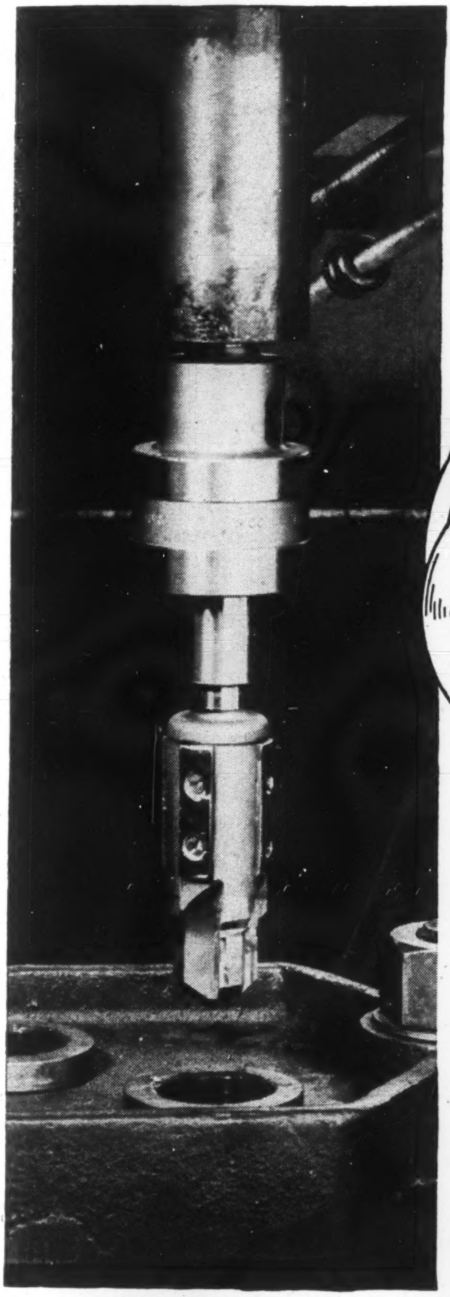
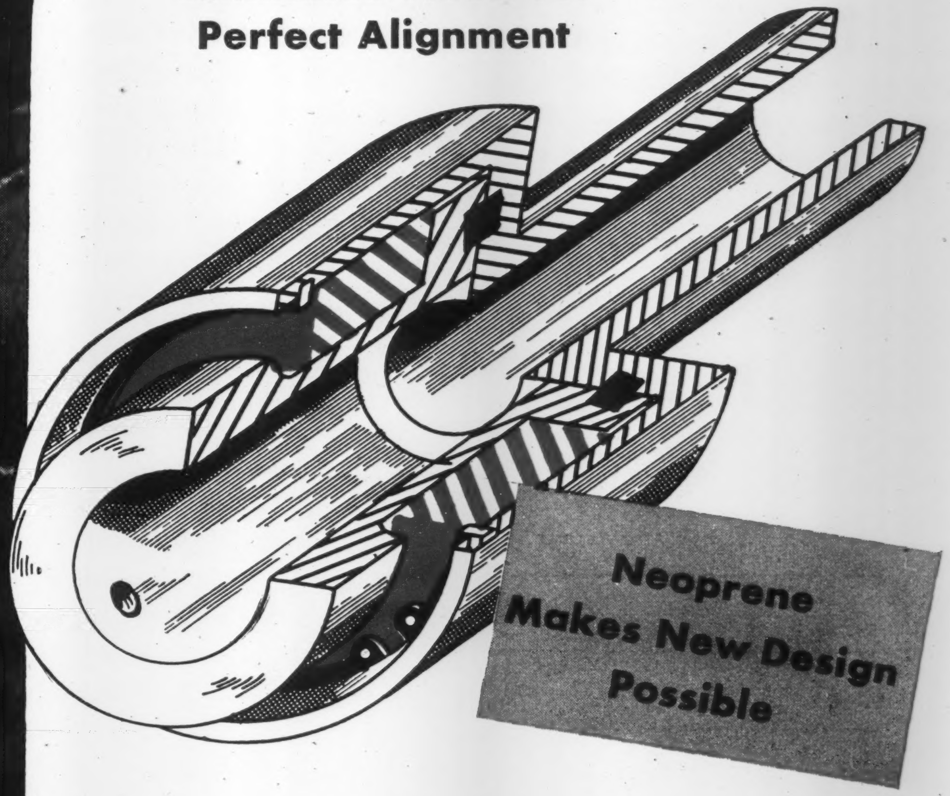


Illustration courtesy of
Burg Tool Manufacturing Company

Eliminates Need For Perfect Alignment

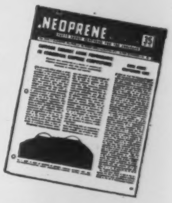


Neoprene Makes New Design Possible

Automatic correction of mis-alignment between tool and work is made possible by the "Tool-Flex" tool holder . . . designed to take advantage of neoprene's unique properties as a tough, cushioning material. The heart of this tool holder is the insert. It must have resilience, low permanent distortion, long life, resistance to heat and oil. A neoprene composition met these requirements.

Neoprene can help you, too—whenever you have a problem involving resiliency and abrasion-resistance, or any of the other properties outlined below. We'll be glad to furnish you technical information. We'll work with your supplier or help find an adequate source of supply for finished neoprene products.

Write today for your free subscription to *The Neoprene Notebook*. Read about the design problems of others, and how neoprene helped in their solution. You may find valuable ideas. E. I. du Pont de Nemours & Co. (Inc.), Rubber Chemicals Div., A-4, Wilmington 98, Del.



Design for success with

NEOPRENE

The rubber made by Du Pont

HERE'S WHY NEOPRENE DOES SO MANY JOBS SO WELL!

- ★ High tensile strength, resilience, low permanent distortion.
- ★ Tough and durable, resists abrasion and cutting.
- ★ Superior resistance to sunlight, aging, ozone, and heat.
- ★ Resistance to deterioration by oils, solvents, chemicals, acids.
- ★ Superior air-retention, low permeability to gases and fluids.
- ★ Special compositions are flame-retarding, static-conducting, flexible at low temperatures.

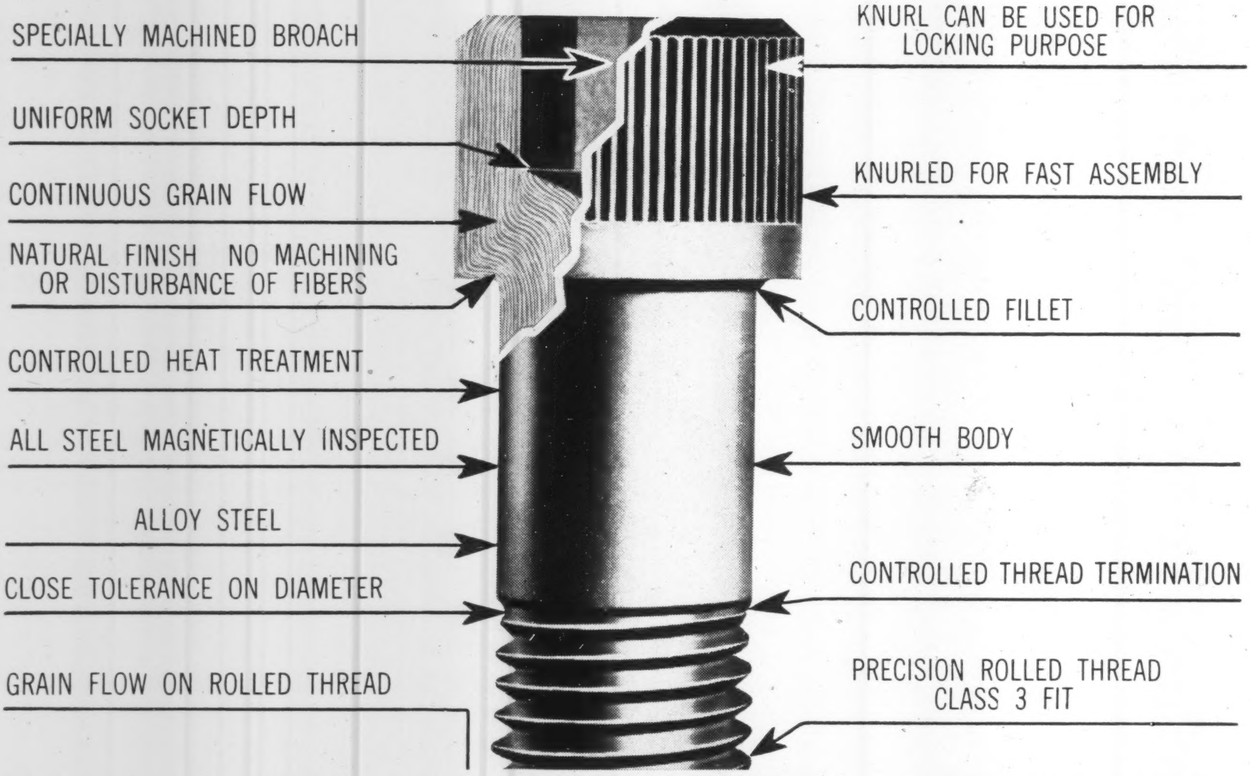
BETTER THINGS FOR BETTER LIVING
. . . *THROUGH CHEMISTRY*

DU PONT
REG. U. S. PAT. OFF.

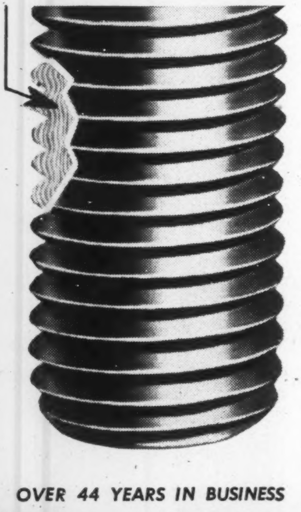
These IMPORTANT FEATURES *of*

UNBRAKO KNURLED SOCKET HEAD CAP SCREWS

REG. U. S. PAT. OFF.


SPECIALLY MACHINED BROACH
UNIFORM SOCKET DEPTH
CONTINUOUS GRAIN FLOW
NATURAL FINISH NO MACHINING OR DISTURBANCE OF FIBERS
CONTROLLED HEAT TREATMENT
ALL STEEL MAGNETICALLY INSPECTED
ALLOY STEEL
CLOSE TOLERANCE ON DIAMETER
GRAIN FLOW ON ROLLED THREAD
KNURL CAN BE USED FOR LOCKING PURPOSE
KNURLED FOR FAST ASSEMBLY
CONTROLLED FILLET
SMOOTH BODY
CONTROLLED THREAD TERMINATION
PRECISION ROLLED THREAD CLASS 3 FIT

Give you these OUTSTANDING ADVANTAGES



STRENGTH, TOUGHNESS, RELIABILITY . . . the result of constant testing, inspection and quality control.

KNURLED HEAD FOR EASY ASSEMBLY . . . the knurled head provides a slip- and fumble-proof grip, even for the most oily fingers, therefore, the screw can be screwed-in faster and farther before it becomes necessary to use a wrench.

EASY START THREAD POINT . . . specially designed to assure fast, easy thread start.

INTERNAL WRENCHING . . . to promote Compact Designs which save space, material, weight and costs. Write for your copy of the "Unbrako" Catalog.

"Unbrako" and "Hallowell" Products are sold entirely through distributors.

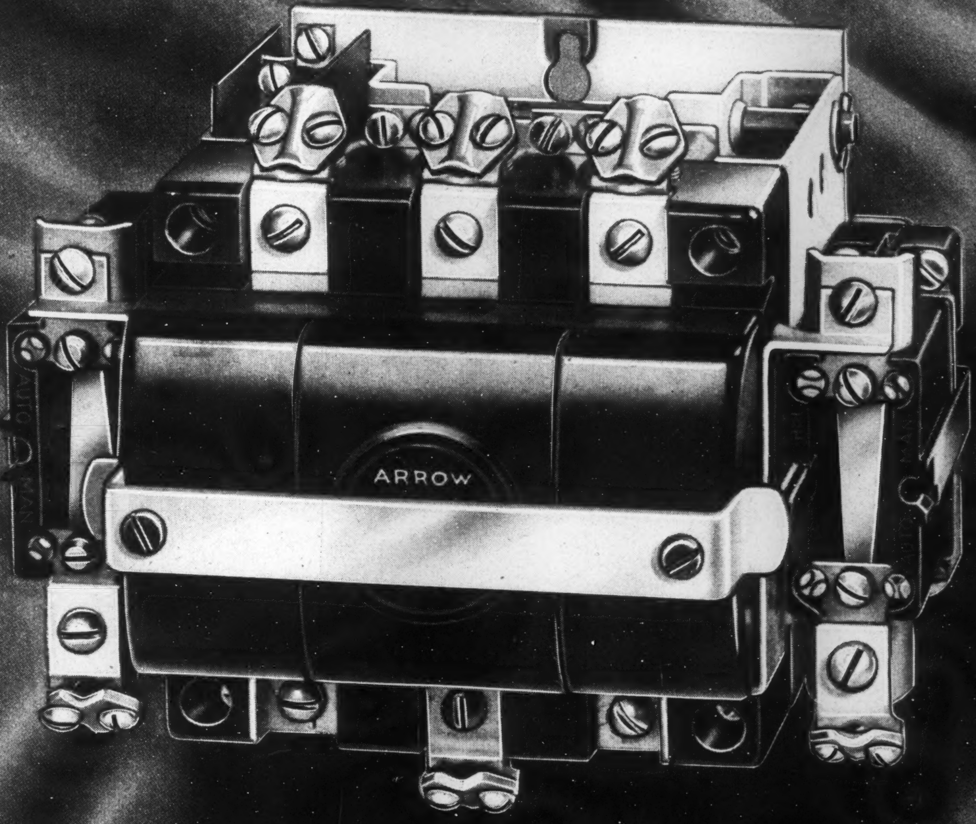
We also make the famous "Unbrako" Socket Set Screw with the "Self-Locking" Knurled Cup Point, and the "Unbrako" Socket Set Screw with the "Self-Locking" Knurled Threads.

OVER 44 YEARS IN BUSINESS

Knurling of Socket Screws originated with "Unbrako" in 1934.

STANDARD PRESSED STEEL CO.

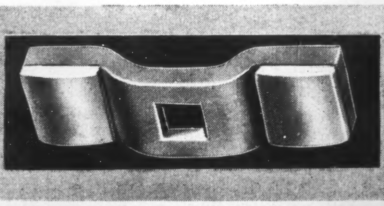
JENKINTOWN, PENNA., BOX 102 • BRANCHES: BOSTON • CHICAGO • DETROIT • INDIANAPOLIS • ST. LOUIS • SAN FRANCISCO



NEW MAGNETIC STARTER

Basic New operating principle of *Balanced Mechanism* is used in this Size 2, Type "RA" Starter. Requires but 8.5 Watts closed, 75 Watts inrush. Moving mechanism is balanced to provide full use of magnet power without lifting extra weight.

Small Size about half that of the conventional Starter for motors up to 25 H. P. Durable, efficient operation ensured by straight-line horizontal action. Designed for straight-through wiring. Write for 4-page illustrated folder.



Contacts WITH CURVED MOVABLE TIPS GIVE BROAD LINE-OF-CONTACT SURFACE

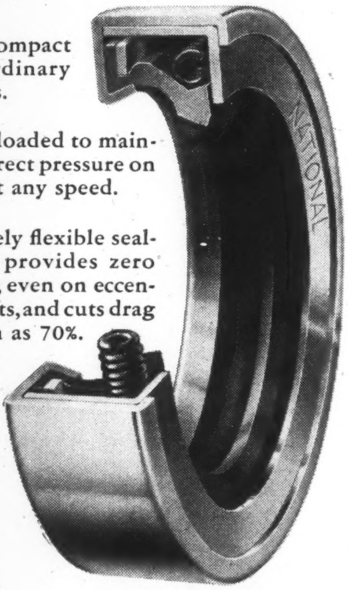
ARROW
AH
HART

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.

Syntech*

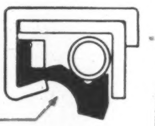
the revolutionary new National Oil Seal gives longer life, zero leakage, reduces power waste

SYNTECH (trademark registered) is an entirely new oil seal which utilizes a special National-developed, synthetic-rubber sealing member.



1. More compact than ordinary oil seals.
2. Spring-loaded to maintain correct pressure on shafts at any speed.
3. Extremely flexible sealing lip provides zero leakage, even on eccentric shafts, and cuts drag as much as 70%.

SYNTECH is made of synthetic rubber compounded to achieve high flexibility and low coefficient of friction.

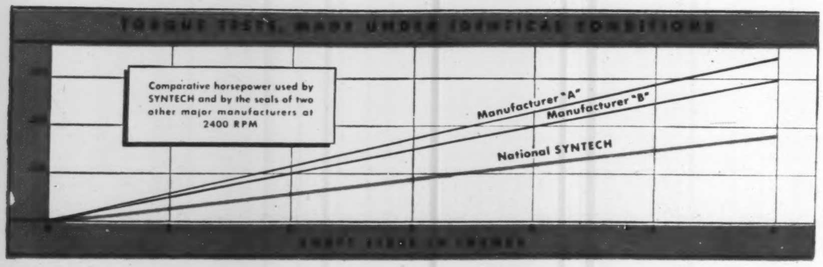


Design of sealing lip provides limited shaft contact.

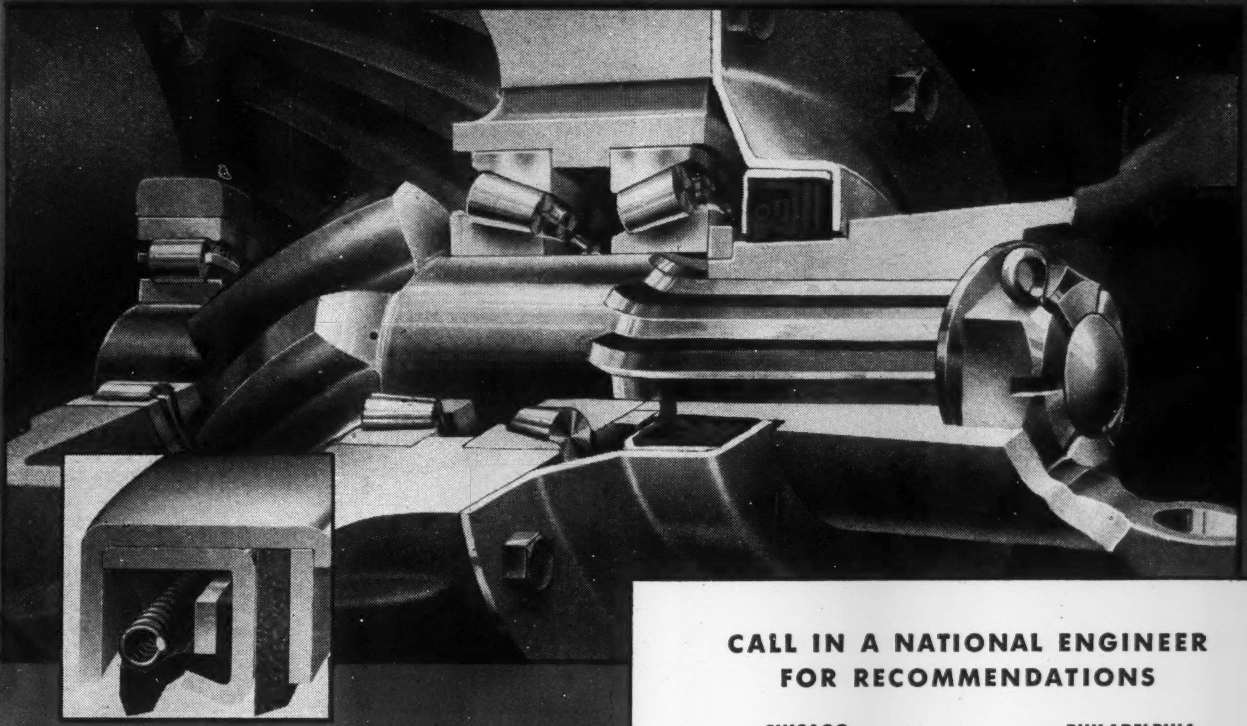
This thin section assures maximum flexibility of the sealing member.

Grueling dynamometer and road tests give positive proof that new National SYNTECH Oil Seals—with the synthetic-rubber sealing member—perform at *zero leakage* over periods up to 10 times the life of a normal application. In addition, SYNTECH safety factors on speed, runout, abrasion and wear far exceed those of other seals tested. And, these optimum sealing results are obtained with astounding reductions in oil seal drag—as shown in the chart below.

Write today to National for more information and samples of these new National SYNTECH Oil Seals. They represent an outstanding step forward in oil seal design and performance.



THE NEW NATIONAL SYNTECH OIL SEALS LAST 100% LONGER ON THE PINION OF THIS NEW LIGHT TRUCK



A leading automotive manufacturer recently solved a serious oil seal problem on the differential pinion of his new light truck. He conducted extensive tests on leading oil retainers—at shaft speeds up to 2000 FPM, and temperatures up to 275°F. The result? Dual-seal National SYNTECH Oil Seals were installed.

The choice was based on engineers' reports, which showed that National SYNTECHS provided positive retention of lubricant plus positive shielding against entry of foreign matter, at all test speeds and temperatures. And the National SYNTECHS lasted 100% longer than the next best oil seals tested.

Whether for trucks, lawnmowers or battleships—wherever shafts turn—you'll find the new National SYNTECH Oil Seal an outstanding improvement over the ordinary types. Let National engineers assist in solving your bearing protection problems. The details of your problem will be kept in strictest confidence.

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

CHICAGO
Room 2014 Field Bldg., Chicago 3
Phone: Central 8663

PHILADELPHIA
401 North Broad St., Philadelphia 8
Phone: Bell-Walnut 2-6997

DETROIT
Room 1026 Fisher Bldg., Detroit 2
Phone: Trinity 16363

NEW YORK CITY
122 East 42nd St., New York City 17
Phone: Lexington 2-8260

MILWAUKEE
1717 E. Kane Place, Milwaukee 2
Phone: Lakeside 2838

HOUSTON
1 Main St., Houston 2, Texas
Phone: Preston 9862

SPRINGFIELD
124 State St., Springfield 3, Mass.
Phone: Springfield 2-1881

KANSAS CITY
1823 Walnut, Kansas City 8, Mo.
Phone: Harrison 6637

CLEVELAND
210 Heights Rockefeller Bldg., Cleveland 18
Phone: Yellowstone 2720

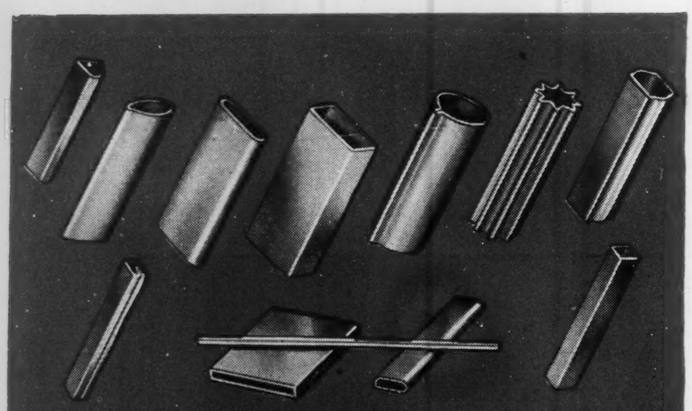
●

NATIONAL MOTOR BEARING COMPANY, INC.
General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, Calif.; Van Wert, Ohio

1351

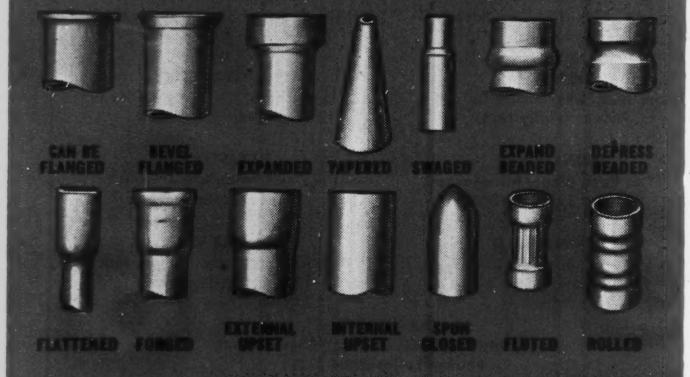
NATIONAL
OIL AND FLUID SEALS

WHEREVER SHAFTS MOVE, THERE'S A NATIONAL SEAL TO RETAIN THE LUBRICANT

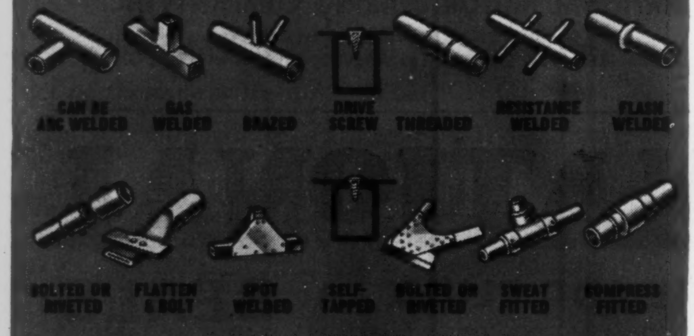


Choice of many shapes, sizes, gauges

Easy to bend in any direction


CAN BE FLANGED
BEVEL FLANGED
EXPANDED
TAPERED
SWAGED
EXPAND BEADED
DEPRESS BEADED
FLATTENED
FORGED
EXTERNAL UPSET
INTERNAL UPSET
SPUN CLOSED
FLUTED
ROLLED

Easy to process in many ways


CAN BE ARC WELDED
GAS WELDED
BRAZED
DRIVE SCREW
THREADED
RESISTANCE WELDED
FLASH WELDED
BOLTED OR RIVETED
FLATTEN & BOLT
SPOT WELDED
SELF-TAPPED
BOLTED OR RIVETED
SWEAT FITTED
COMPRESS FITTED

Easy to assemble by many methods

MORE and MORE

"Standard" Shows the Way to More Tubing Uses . . .

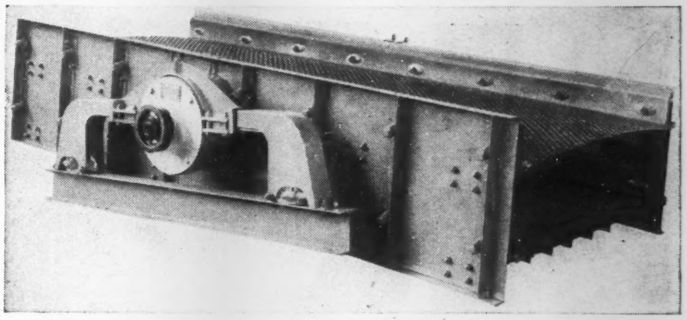
For Example: The Standard Tube Company, leading specialist in electric welded steel tubing, is working with more and more manufacturers in the automotive field to help simplify designing, fabricating and assembling processes for greater economy. *"Standard's"* variety of tube shapes, sizes and gauges—available in carbon steels, stainless, and N-A-X high tensile steels—are daily proving more advantageous for new uses . . . not only in the automotive industry, but also in countless other industries.

As shown at left, you can easily bend *"Standard"* tubing, change its cross section, and assemble it by many methods. Perhaps we can help *you* figure a more profitable production method, by using *"Standard"* . . . the *quality* tubing with a weld of the same uniform strength, and physical characteristics, as the tube wall itself!

Standardize with "Standard"—It Pays!

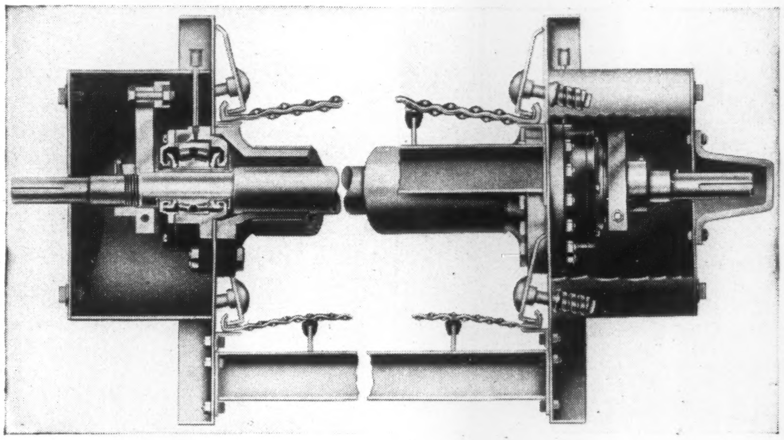
THE STANDARD TUBE CO.
Detroit 3, STANDARD Michigan
Welded Tubing
Fabricated Parts
STANDARDIZE with "STANDARD"—It Pays

★ *Complete Tube Stocks Maintained by* ★
STANDARD TUBE SALES CORP., One Admiral Ave., Maspeth, L. I., N. Y.
LAPHAM-HICKEY COMPANY, 3333 W. 47th Place, Chicago 32, Ill.
UNION HARDWARE & METAL CO., 411 E. First St., Los Angeles 54, Cal.
THE PACIFIC PIPE COMPANY., 160 Spear St., San Francisco 5, Cal.



Style M Vibrex Screen built by Robins Conveyors, Div., Hewitt-Robins, Inc.

Protecting Vibrex Screens against Bearing Trouble



- *Two SKF Spherical Roller Bearings are on the Vibrator Shaft*

The vibrator shaft of this Vibrex Screen runs in rugged SKF Spherical Roller Bearings mounted in individual flanged cartridge units. The bearings are protected by a highly efficient combination flinger and labyrinth seal suitable for either oil or light grease lubrication. The inner race of each bearing unit is pressed onto a sleeve which is keyed to the drive shaft, permitting each complete bearing unit to be removed easily without using any special tools or disturbing any fit. Our engineers will be glad to give you information concerning the application of SKF's to screens. 6204

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

SKF
BALL AND ROLLER
BEARINGS

K-68
RAYBESTOS MANHATTAN
K68
a new gasket material
for gasoline engines
for Diesels
for refrigeration equipment
for refineries

K-68 is a new type of gasket sheet of special synthetic rubber and long-fibre asbestos, produced by R/M after more than ten years of experimentation.

K-68 meets specification AMS-3232 E. It has high tensile strength and great resistance to hot petroleum oils, light fuels and aromatic fractions. After oil immersion, its tensile strength remains between 90% and 100% of its original value. Swelling after fuel immersion is less than 15%.

K-68 contains no sulphur . . . making it valuable for refrigeration equipment.

This exceptional new sheet, with its many different applications, is now being made by R/M in large quantities, in thicknesses from 1/64″ to 1/8″ and in widths up to 60″. Specify K-68 when you order gaskets.

K-68 is just one of many packings made by R/M to meet special conditions. A large staff of engineers, thoroughly experienced in packing problems, and the complete facilities of Raybestos-Manhattan, Inc., are available to develop and supply the packings needed for your equipment.

RAYBESTOS-MANHATTAN, INC.

ASBESTOS TEXTILE & PACKING DIVISION

MANHEIM, PA. • BRIDGEPORT, CONN. • NORTH CHARLESTON, S. C. • PASSAIC, N. J.

It's "Packed with Satisfaction" When You Use R/M

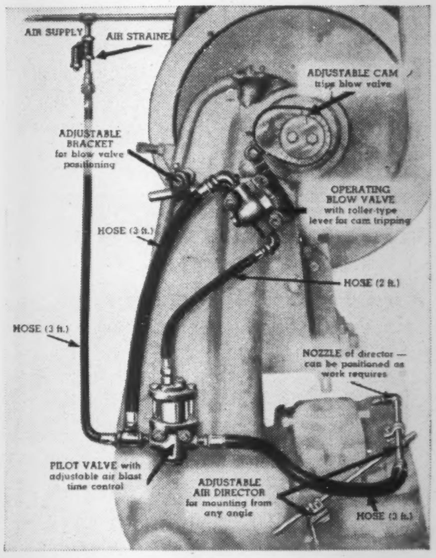
"Now you see it—
Now you don't"

SCHRADER AIR EJECTION SETS PUT NEW LIFE INTO OLD PRESSES

Compressed air efficiently controlled by Schrader Air Ejection Sets eliminates the use of mechanical knockouts or the manual removal of finished work from dies. Parts are removed from the die by a regulated stream of air, timed to a fraction of a second by an air-saving pilot valve. Work may be automatically ejected after forming. Can be timed to eject work at any time during cycle when necessary.

The Schrader Air Ejection Set hook-up shown at the right clearly illustrates how this intermittent principle works cutting down a wasteful steady air flow. You can increase your production and safety, and lower costs by installing Schrader Air Ejection Sets on all your power presses now. Schrader sets are assembled and packaged with bolts, and instructions for installing and timing.

For complete information write for the helpful air ejection set bulletin, Dept. 9.


AIR SUPPLY
AIR STRAINER
ADJUSTABLE CAM trips blow valve
ADJUSTABLE BRACKET for blow valve positioning
OPERATING BLOW VALVE with roller-type lever for cam tripping
HOSE (3 ft.)
HOSE (2 ft.)
HOSE (3 ft.)
NOZZLE of director — can be positioned as work requires
PILOT VALVE with adjustable air blast time control
ADJUSTABLE AIR DIRECTOR for mounting from any angle
HOSE (3 ft.)

Set No. 1508 (cam-operated) with timed Air Blast. Also available for Ram operation. Schrader Air Ejection Sets eliminate hand operation, increase production and slash costs.

Everything for Efficient Air Control

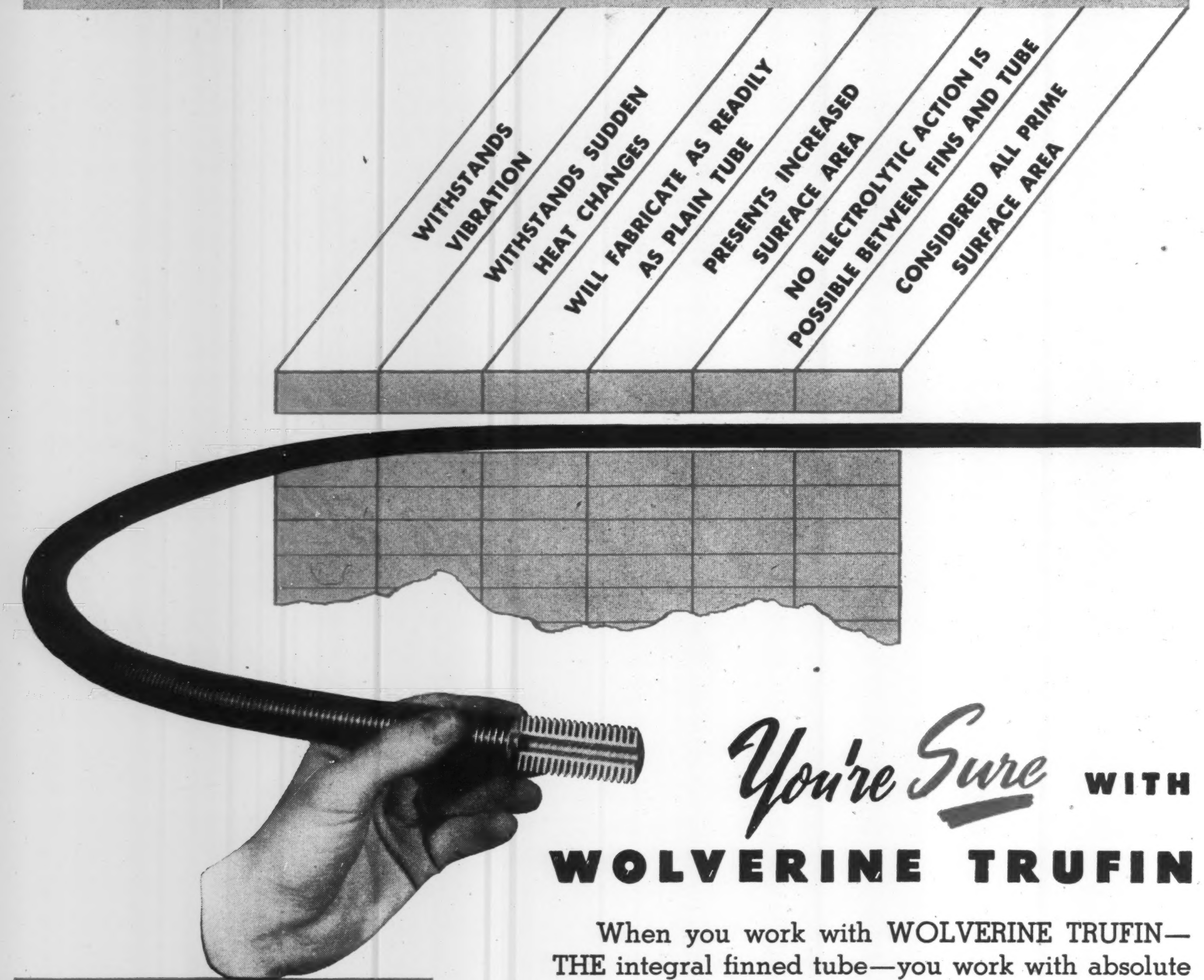
- **Air Cylinders, Operating Valves 2, 3 and 4-way (hand, foot and remote control), Safety and Operating Controls, Air Ejection (Knockout) Sets, Pneumatic Machine Controls (all types), Quick Acting Couplers, Blow Guns, Air Hose and Fittings, Hydraulic Gauges.**

A. SCHRADER'S SON, BROOKLYN 17, NEW YORK

Division of Scovill Manufacturing Company, Incorporated

Schrader
PRODUCTS
CONTROL THE AIR

PEGGED PERFORMANCE


WITHSTANDS VIBRATION
WITHSTANDS SUDDEN HEAT CHANGES
WILL FABRICATE AS READILY AS PLAIN TUBE
PRESENTS INCREASED SURFACE AREA
NO ELECTROLYTIC ACTION IS POSSIBLE BETWEEN FINS AND TUBE
CONSIDERED ALL PRIME SURFACE AREA

You're Sure WITH WOLVERINE TRUFIN

When you work with WOLVERINE TRUFIN—THE integral finned tube—you work with absolute factors. As many of our customers have reiterated, "You can peg performance with Trufin."

In calculating a given heat transfer problem, for example, you need not use intangibles since ALL Trufin surface is generally considered *prime* surface.

You can depend on Trufin giving high performance even where vibration or extreme heat changes are encountered.

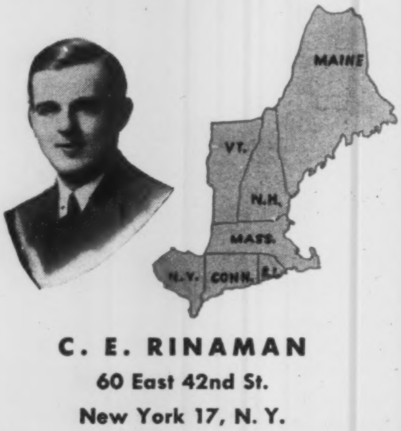
Besides the advantage of increased surface area, this all-one-piece finned tube is capable of being bent, formed, or otherwise fabricated as easily as plain tube.

Send for our Engineering pamphlets.

WOLVERINE TUBE DIVISION

Calumet & Hecla Consolidated Copper Company
1411 CENTRAL AVENUE • DETROIT 9, MICHIGAN

WHO'S WHO AMONG WOLVERINE REPRESENTATIVES


MAINE
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C. E. RINAMAN
60 East 42nd St.
New York 17, N. Y.

Represents Wolverine in Manhattan, Greater New York, and a host of accounts in New England.

STEEL BACK
BRONZE PARTS
BRONZE BACK
LARGE SIZES

Sleeve Bearings

TO FIT THE JOB!

We design and manufacture a wide range of types and sizes of *silent* sleeve bearings and bushings, plain and flanged, full round and split, as well as a great variety of precision bronze parts. Our engineering department can aid in preparing specifications that fit both performance and cost requirements. Each of our manufacturing plants specializes in bearing manufacture within a specific range of size, volume and alloy combinations, resulting in facilities for both large volume production and small runs. Thrust washers and precision bronze parts—and large bearings up to 27" diameter are a specialty.

FEDERAL-MOGUL CORPORATION, 11045 Shoemaker, Detroit 13, Mich.

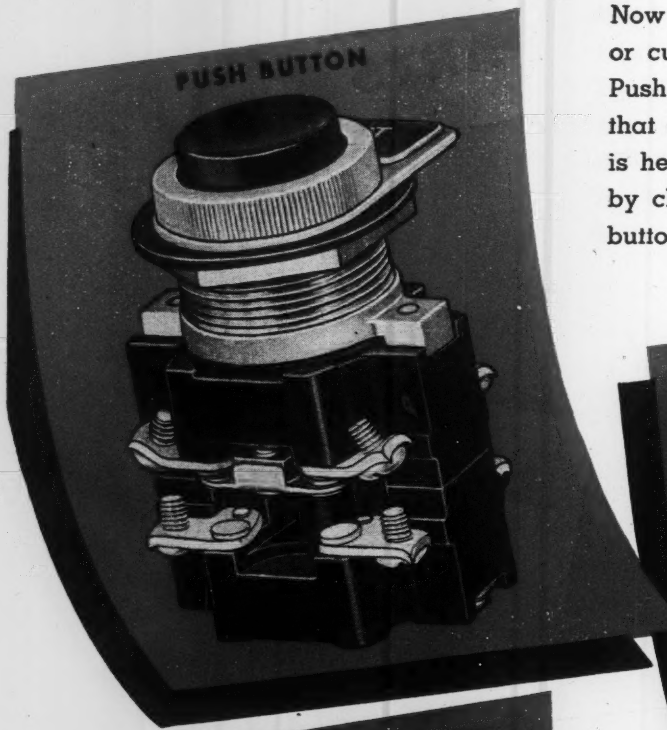
FEDERAL-MOGUL

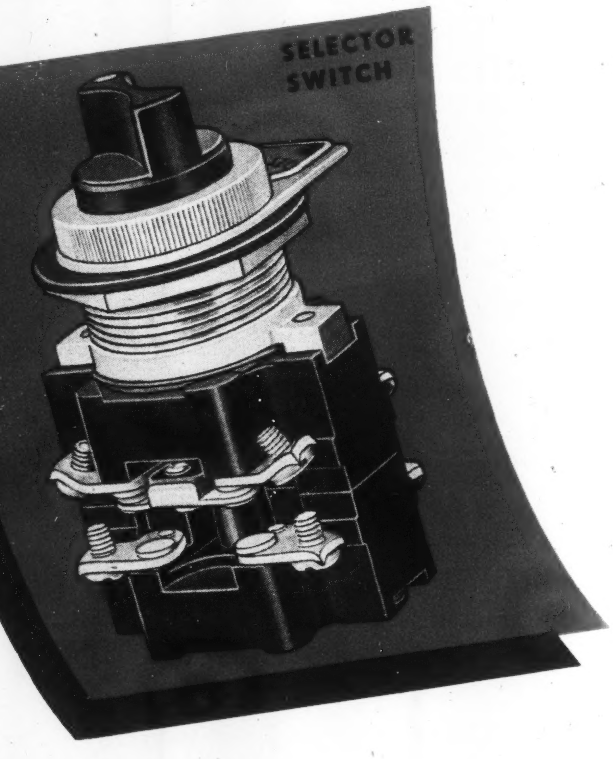
Silent FEDERAL Mogul SLEEVE BEARINGS

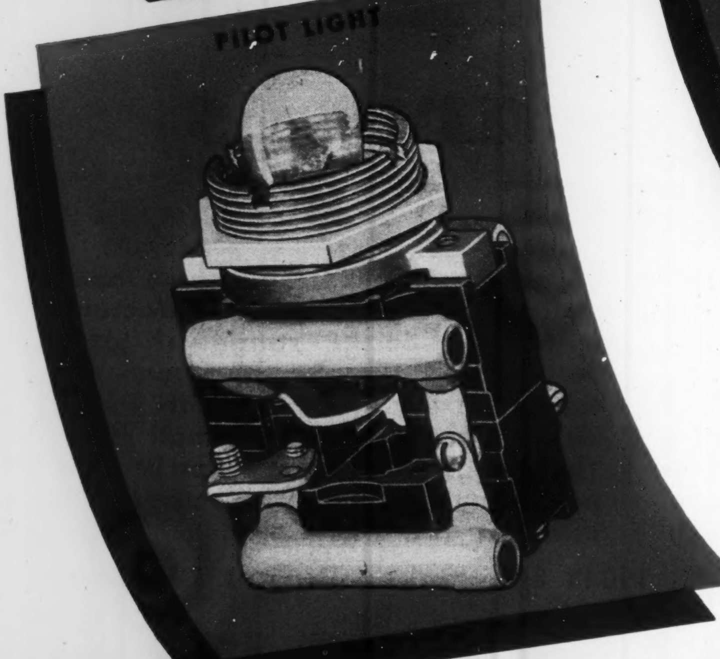
Another "3C" Achievement!

PERMANENTLY OIL TIGHT PUSH BUTTON, PILOT LIGHTS *and* SELECTOR SWITCHES *for use on Machine Tools*

Now you can avoid fouling contacts from seepage of oil or cutting compounds with these new "3C" developed Push Button Elements, Pilot Lights and Selector Switches that are *entirely oil tight.* A steel faced oil-tight washer is held snugly against both front and rear of the panel by close fitting nuts. An oil-tight boot closely grips the button, effectively sealing it against leakage.





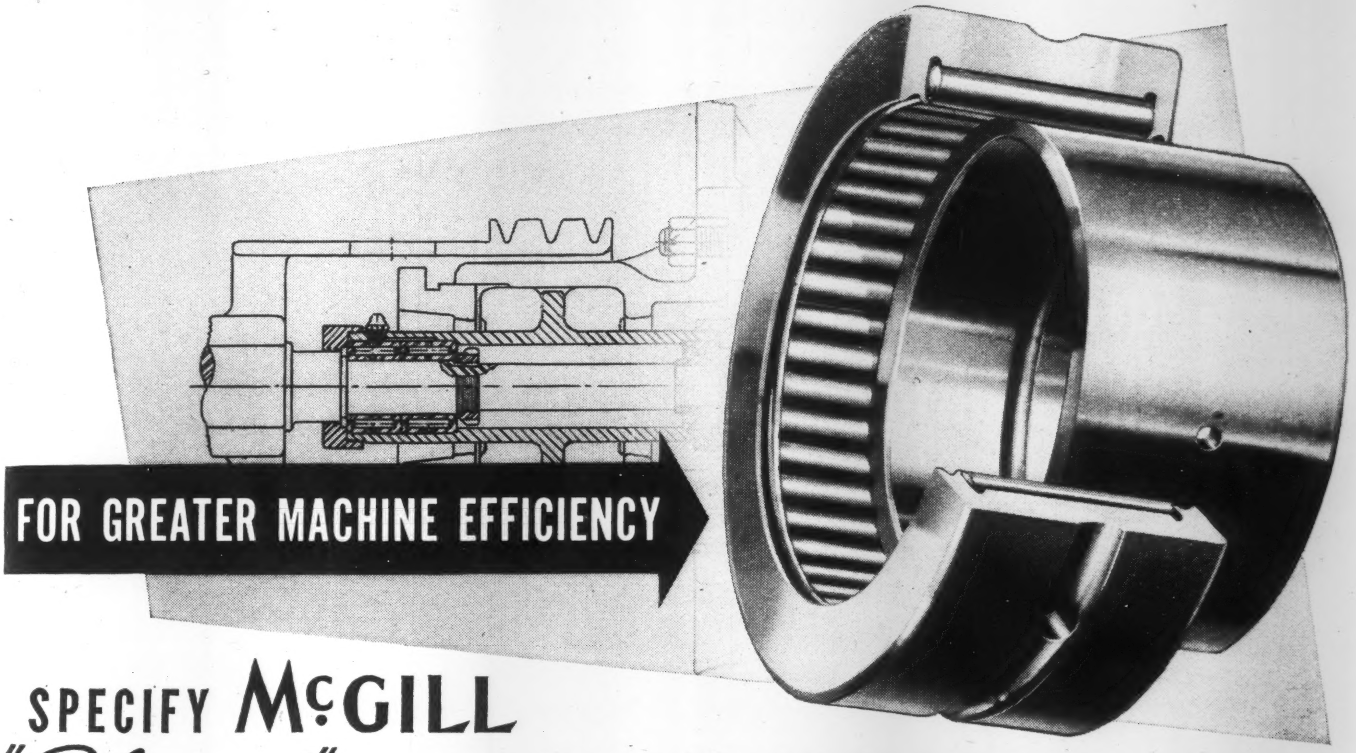


These heavy-duty Type DO units have the same basic elements as the "3C" Type "D" units which have established such excellent records in heavy-duty use. Push Buttons and Selector Switches feature Silver-to-Silver Double Break Contacts. All units have large, easily accessible terminals that simplify wiring. Selector Switch permits 2 or 3 position operation. Vertical mounting is standard, but all units are adaptable to horizontal mounting. Mushroom head available for Push Button. Color caps for Pilot Lights are available in Red, Green, Amber, Blue, Clear and White.

Write for full information.

THE CLARK CONTROLLER CO.

EVERYTHING UNDER CONTROL • 1146 EAST 152nd STREET, CLEVELAND 10, OHIO



SPECIFY McGILL "Solidend" MULTIROL* BEARINGS

• MORE LOAD CAPACITY

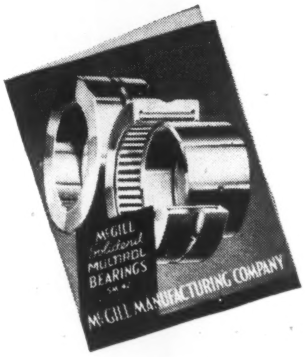
The "Solidend" *MULTIROL* design specifies roller ends that increase effective roller length. This provides a maximum race and roller-load carrying-contact. Superior design and the best in bearing steel assures the ultimate in full type roller bearing capacity.

• LONGER LIFE

Rigidity of construction and adequate lubrication facilities—including a reservoir in the outer race—guarantees minimum wear and longer life. Specially formed shoulder lips eliminate delicate washers and roller retaining rings.

• COMPACTNESS

An important design feature of the McGill "Solidend" *MULTIROL* Bearing is compactness. The bearing can be used without the inner race. This application is especially appreciated when greater load carrying capacity is required and radial space is limited.



Bulletin SM-42 contains complete engineering data. Write for your copy.

*Trade Mark Registered

McGILL MANUFACTURING CO., INC. **VALPARAISO, IND.**

200 North Lafayette Street

MANUFACTURERS OF BALL AND ROLLER BEARINGS

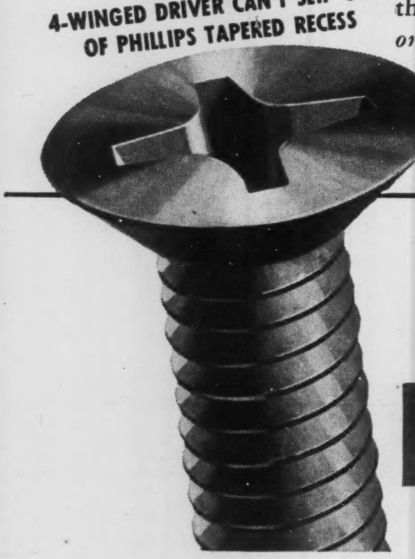
Many Sunlamp Makers
(and users, too)
are "Seeing the Light"

...by insisting on AMERICAN PHILLIPS SCREWS

PRODUCTION-WISE – add sunlamp manufacturers to the host of stove, refrigerator, furniture and other modern-minded makers who are cutting production costs via American Phillips Screws. How? By straight, sure-fire, speedy, *automatic* driving that's proof against scars, scuffs, work spoilage. No matter what the pace, the 4-winged American Phillips Driver "stays put" — can't harm or hinder work or worker . . . and you can count on *time savings up to 50%!*

PROMOTION-WISE – American Phillips Screws lend a modern touch — step up the "sell" of whatever you make. They can't snag clothes but they *do* snag *orders!* Showmanship and serviceability both say "specify American Phillips."

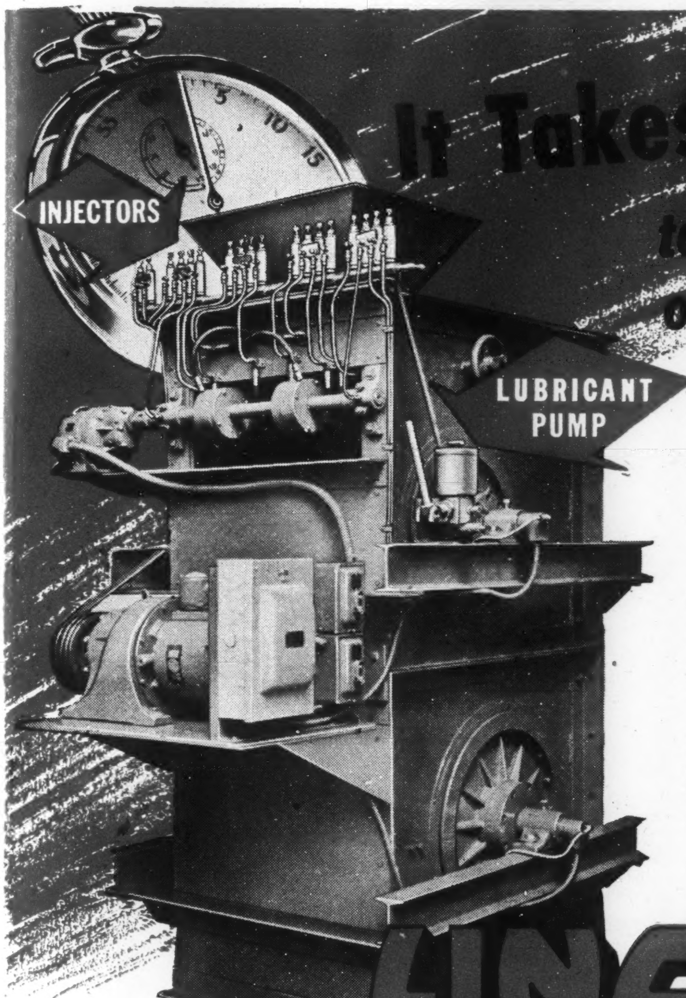
4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS



AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND
Chicago 11: 589 E. Illinois St. *Detroit 2: 502 Stephenson Bldg.*

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)



It Takes Only SECONDS to LUBRICATE every Bearing on this MACHINE . . .

When a manufacturer includes a Lincoln Centro-Matic System to lubricate the bearings on the machines which he produces, he provides the user with a fast, thorough lubricating system and assures him of top operating efficiency.

There is a Lincoln Centro-Matic System to meet the requirements of each particular machine. It consists of a pump, an injector of suitable size for each bearing, a single supply line to connect the pump to the injectors, and a tubing connection from an injector to each bearing. Pumps are available for hand, air or electric operation. The electric and air pumps may be equipped with a time clock for full automatic operation if desired.

LINCOLN

A Dings Magnetic Separator with Lincoln Centro-Matic System.

Single Line
CENTRO-MATIC LUBRICATING SYSTEMS
used on Hundreds of Machines . . .

☐ Angle Shears
☐ Agitators
☐ Bottling Machinery
☐ Brick Presses
☐ Boats
☐ Bolters
☐ Boring Machines
☐ Bar Mills
☐ Bar Straighteners
☐ Back Geared Presses
☐ Brake Presses
☐ Blast Furnaces
☐ Cranes
☐ Crimpers
☐ Centerless Grinders
☐ Candy Machinery
☐ Cutters
☐ Chemical Machinery
☐ Cold Roll Mills
☐ Conveyors
☐ Coal Loaders
☐ Coke Quenching Cars
☐ Chip Stokers
☐ Crushers
☐ Caramel Cutters
☐ Cookers
☐ Coilers
☐ Dry Presses
☐ Drying Machines
☐ Duplicators
☐ Die Casters
☐ Draw Benches
☐ Electric Shovels
☐ Forging Machines
☐ Forming Presses
☐ Filter Presses
☐ Filtering Equipment
☐ Grain Presses
☐ Grinders
☐ Hydraulic Presses
☐ Lathes
☐ Locomotives
☐ Mixers
☐ Mine Tipples
☐ Metal Reclaimers
☐ Pasting Machinery
☐ Punch Presses
☐ Printing Presses
☐ Plastic Presses
☐ Processing Machinery
☐ Packaging Machinery
☐ Plate Shears
☐ Rubber Mills
☐ Rolling Mills
☐ Roll Squeezers
☐ Separators
☐ Steam Shovels
☐ Spacing Machines
☐ Starch Bucks
☐ Screw Conveyors
☐ Slab Mills
☐ Shears
☐ Tube Coiling Machinery
☐ Tow Boats
☐ Tin Plate Machines
☐ Veneer Dryers
☐ Wall Board Machines

Engineering Service

Lincoln Engineering Company maintains a staff of experienced lubrication engineers prepared to assist you with lubricating problems. Write us, enclosing a blueprint or specifications of the machine, and we will recommend the type of Centro-Matic System best suited.

Lincoln Engineering Company • St. Louis 20, Mo.

Please give me information on Centro-Matic Systems for (type of machine) ________________

Please send me literature on Centro-Matic Systems ☐.

Name____________________

Firm____________________

Address____________________

City__________State__________

MD 847-3

It Had Us *Stumped!*

How to describe HOLLISTON Special Purpose Fabrics so that *you* will immediately recognize a use for them in *your* industry? That is the problem; and it has us stumped. Because these amazing fabrics have so many variable characteristics, so many potential uses. For instance, they can be flame-resistant and water-repellent. They can be impervious to mild acids, alkalies and solvents. They can be endowed with surprising dielectric and accoustic properties. They can be any or all of these things. What do they look like? They can be made to simulate almost any material you wish, for they can be fine as silk or coarse as burlap and either limp or stiff. Many HOLLISTON Special Purpose Fabrics are already serving industry daily. Most likely there is a HOLLISTON Fabric that will meet all your requirements. Find out today!

HOLLISTON

Special Purpose Fabrics

THE HOLLISTON MILLS, INC., NORWOOD, MASSACHUSETTS

GEAR
HIGHLIGHTS

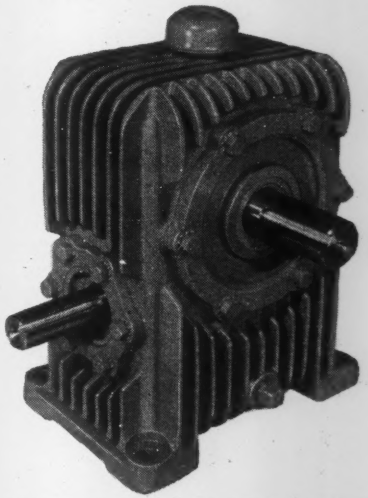
VOL. XI NO. 2

This is page 1 of the current issue. Write for the complete issue today.

ALSO IN THIS ISSUE

How to Get Extra Tool Life Free . . . . p. 4
New Literature Available . . p. 4
New Minnesota Representative . . . . p. 4

STANDARDIZED CONE-DRIVE SPEED REDUCERS NOW AVAILABLE



A complete standardized line of speed reducers, built around double enveloping Cone-Drive gearing is now in quantity production at the Cone-Drive plant of Michigan Tool Company in models to suit practically every requirement. The horsepower and torque these units will transmit for a given size is quite startling to anyone not familiar with Cone-Drive gearing.

The new standardized line includes models with pinion under, pinion over, and with gear shaft vertical. The center distances of from 2 to 18 inches cover a power-transmission range equivalent to 3″ to 24″ center distance in worm

(Continued on page 3)

UNDERPASS CURVE-SHAVING *Features* WISCONSIN AXLE'S PRODUCTION OF LARGE GEARS TO HIGH PRECISION

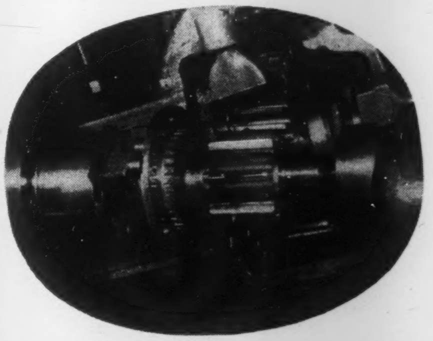
by PERRY L. ADAMS, Gear Superintendent
Wisconsin Axle Division—Timken-Detroit Axle Co.

Since the introduction of shaving into the gear manufacturing cycle, including the curve-shaving of pinions—and particularly since the Underpass method of shaving has been adopted, Wisconsin Axle Division of Timken-Detroit Axle Company, Oshkosh, Wisconsin, has not only been able to reduce manufacturing time and costs but has also been able to improve gear quality. Among the benefits reported are:

1. Less variation in involute form
2. More accurate tooth spacing
3. Correction of lead errors
4. More desirable mating contact between gears
5. Production output increase

These improvements result in corresponding improvements in the service life and quietness of the heavy duty gears which Wis-

(Continued on page 2)



MICHIGAN "SINE-LINE" LEAD — COMPARATORS —

Known as models 1200 and 1200A, virtually foolproof Michigan lead comparators are available for use on the production floor alongside gear cutting and shaving machines. The master multiple thread lead, followers, indicators and actuating mechanisms are all enclosed.

Machines may be used as an aid in setting up gear cutting and finishing machines, to check gears after processing, to determine lead compensation for "unwinding" of gears during heat-treat, etc.

They are applicable to both external and internal gears as well as worms. To change the machine over for checking gears of differ-

(Continued on page 4)

MICHIGAN TOOL COMPANY
7171 East McNichols Road
DETROIT 12, - - U.S.A.

MOULDED RUBBER PRODUCTS

PRECISION-MADE TO CLOSE TOLERANCES FOR *Your* SPECIFIC APPLICATION

Linear has, for more than forty years, specialized in the design, development, manufacture and application of natural and synthetic rubber compounds to the Mechanical Packing and Moulded Rubber requirements of a wide variety of industrial installations.

Every Linear Moulded Rubber Product is custom-made for your job . . . a special-purpose moulding designed, engineered and precision-made for your specific need.

Our Engineers are always available to help you select the correct type of moulding for your application . . . to determine not only the best natural or synthetic rubber compound, but the most effective design to fit your service conditions.

For further information about Linear Quality Moulded Rubber Products, write

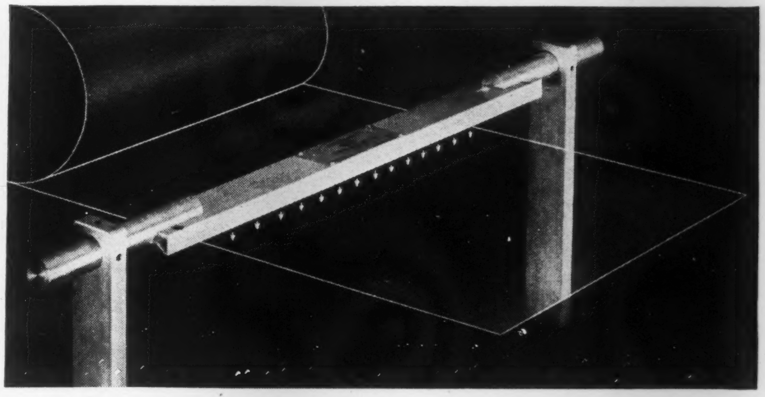
LINEAR
INCORPORATED

OVER FORTY YEARS PACKING EXPERIENCE

Executive Offices and Factory
STATE ROAD and LEVICK STREET—PHILADELPHIA 35, PENNA.

NOW... putting an end to static troubles...

- ***. . . on coating and finishing machines***
- ***. . . packaging and envelope machines***
- ***. . . printing presses***
- ***. . . production and processing equipment for cellulose sheeting, cellophane, glassine, rubber, synthetics, paper stocks***
- ***. . . textile machinery***
- ***. . . photographic print driers***
- ***. . . microbalances***



The Ionotron employs a *new method* of eliminating static electricity — a unique method with exclusive, basic advantages. Continuous alpha radiation is provided by a radioactive source in a metallic bar-shaped housing of suitable size for the specific equipment. The rays ionize the air in the critical zone. The ionized air "bleeds off" static charges before they can cause trouble. The Ionotron is continuously and permanently effective. No power connection is required, and there's no operating expense!

Interrupted production due to difficulties in handling static-charged materials . . . irregularities in finished products . . . fire and explosion hazards — all these are common problems in operations where friction generates static electricity. The Ionotron Static Eliminator*, a recent achievement of the U. S. Radium Corporation, affords you a simple yet highly effective means of eliminating such problems from the machines you design or the equipment you use.

The efficiency and safety of many types of machines have been increased by the installation of Ionotron units. By incorporating the Ionotron into your design, you can give many machines an important additional sales feature. Application of the Ionotron is so simple that it rarely necessitates any modification of fundamental design.

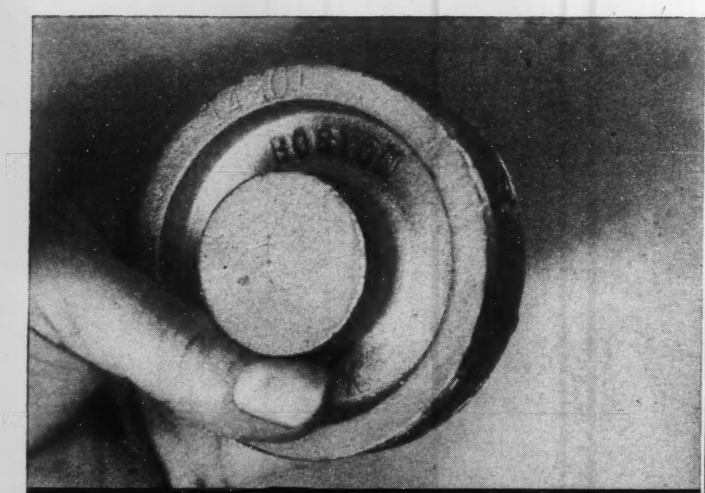
To find out more about how the Ionotron works, write for Bulletin 8.1. Or, better still, send us a sketch or blueprint and description of any static "trouble spot" you have, and we'll submit specific recommendations, without obligation. Write *Dept. H2, U. S. Radium Corp., 535 Pearl St., New York 17, N. Y.*

U S RADIUM

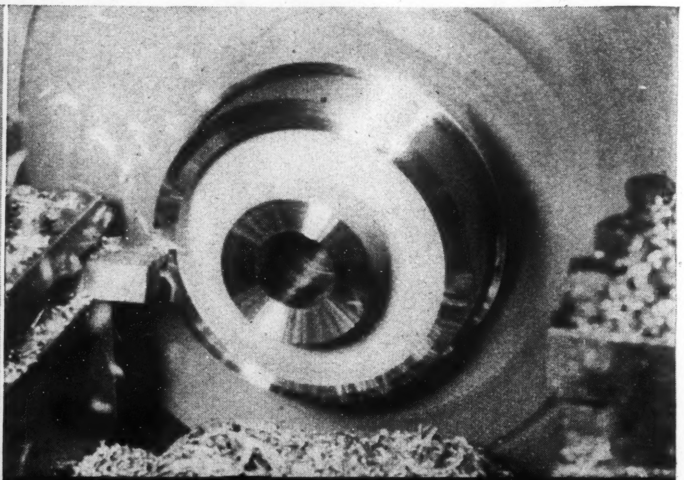
IONOTRON *Static* ELIMINATOR

*Trade-mark reg. U. S. Pat. Off.

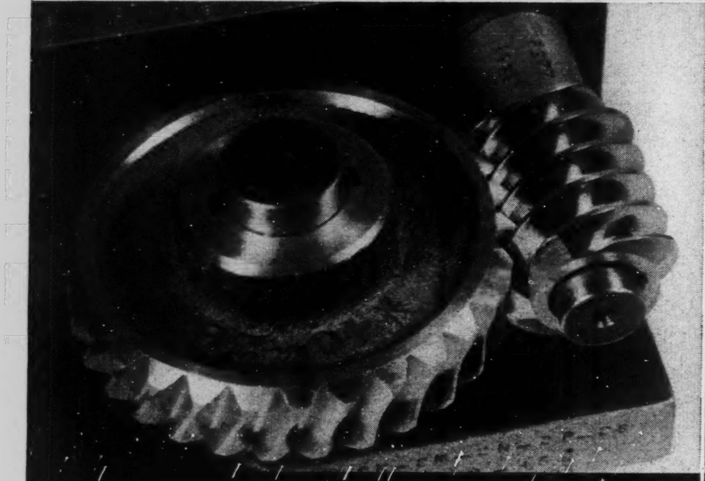
OTHER PRODUCTS OF U. S. RADIUM: LUMINESCENT MATERIALS: *radioactive, fluorescent, phosphorescent* • **LUMINESCENT DIALS:** *radioactive, fluorescent* • **POWDERS:** *cathode-ray tube television tube* • **RADIUM LOCATORS:** *pendants, lenses, buttons, screws, markers* • **RADIOACTIVE FOILS** *(alpha-ray ionization sources)* • **HIGH-ACCURACY DIALS** *(nonluminescent)* • **SILHOUETTE ILLUMINATION** *of clocks, watches, and instruments* **LUMINOUS RETICLES** *and other specialties*



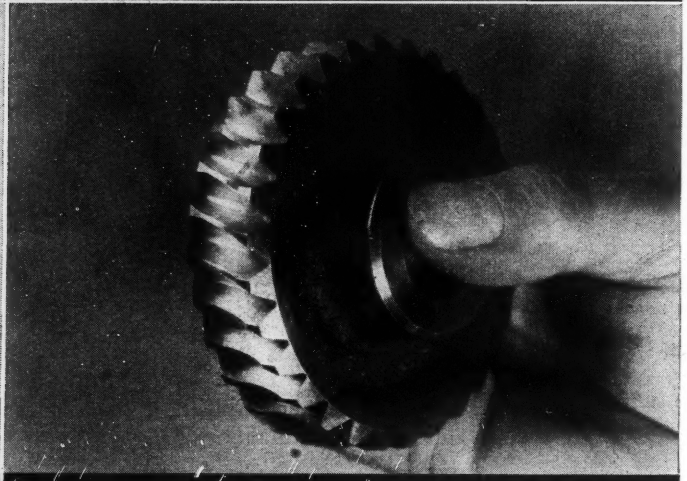
THE ROUGH WORM GEAR CASTING



TURNING THE WORM GEAR CASTING



INSPECTION WITH MASTER WORM



THE FINISHED WORM GEAR

There is NO substitute for Quality

Manufacturing a complete line of stock gears embodies a multitude of machining operations. Each gear that we list in our catalog is made to pre-determined standards and reviewed as new machines, tools and methods come into use. Inspection at key points in the production run is most important. We must maintain our quality to insure interchangeability. Repeat orders for stock gears must carry the assurance that the quality is the same as furnished previously. This is why we maintain a high standard of manufacture as — there is *no* substitute for quality.

BOSTON

Power Transmission Equipment & Component Machine Parts

FROM STOCK!

CATALOG NO. 54

If you are interested in quality stock gears and do not have a copy of our General Catalog No. 54 — simply write us a postcard or letter — we'll be glad to send you a copy.

The Boston Gear Line Is Stocked By Distributors In Over 60 Cities From Coast To Coast

BOSTON GEAR WORKS, INC. NORTH QUINCY, MASSACHUSETTS

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☐ SAND
☐ PERMANENT MOLD
☐ DIE

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Ask us which type of Aluminum Casting is best for your product . . . and you get a frank, technically-sound answer. We make all three types, have no special bias in favor of any one of the three. Our job is to see that you use the casting that's best for your product . . . and for your production cost figures.

Each type of Alcoa Aluminum Casting—sand, permanent mold, and die—has its points. Your product may require a combination of two types, or even all three.

Our engineers and our 59 years of aluminum know-how are at your service to help you get the most from Alcoa Aluminum Castings. ALUMINUM COMPANY OF AMERICA, 1940 Gulf Bldg., Pittsburgh 19, Penna. Sales offices in leading cities.

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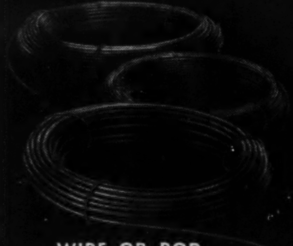
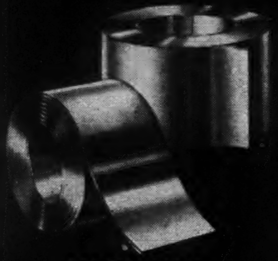

WIRE OR ROD


SOLDER STRIP

POWDERED SOLDER

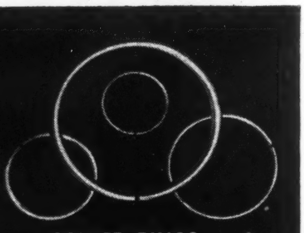
BURRED SOLDER

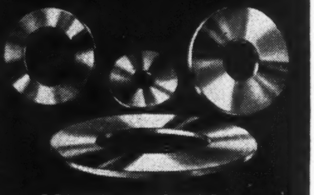
The D. E. Makepeace Company has long pioneered in the development of silver solders. With more than a half century of accumulated experience behind us, we have, today, developed a variety of silver-brazing alloys to meet practically every industrial requirement.

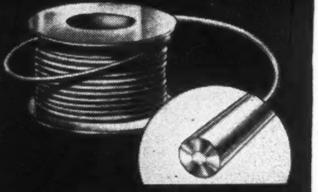
These solders flow easily, penetrate deeply and diffuse evenly. The joints so affected are stronger, in most instances, than the parts joined and the junction is durable, ductile, leakproof, corrosion resistant, and high in electrical and thermal conductivity.

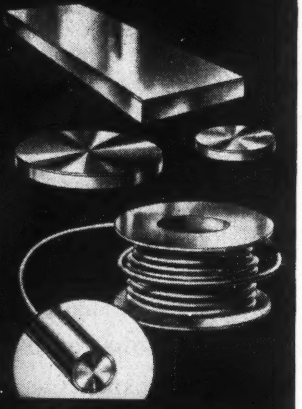
Today, preplaced solder rings or solder washers and induction heating are revolutionizing former soldering methods. Likewise, modern alloys and light gauge metals, likely to be damaged by high temperature brazing or welding, have been particularly aided by the use of our low temperature, fast spreading silver solders.

Should you have a special soldering or brazing ploblem, our fully equipped research and testing laboratory is at your service. Our informative folder listing precious metal solders, with helpful melting and flow-point tables, will be sent you upon request.


SOLDER RINGS


SOLDER WASHERS


SOLDER FILLED WIRE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FLEXIBLE COUPLINGS

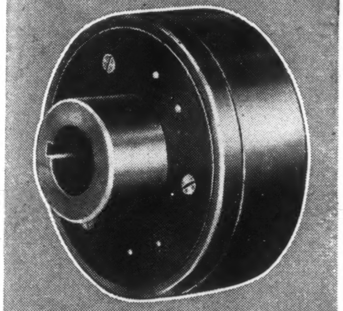
PHILLIE GEAR

—*any* SIZE *or* TYPE ...*for any service*

We make or distribute various types of couplings in both the rigid and flexible styles, and our recommendations are based upon the actual experience our Engineering Department has had with various couplings in service. . . . Thus, our customers can be assured of an unbiased recommendation.

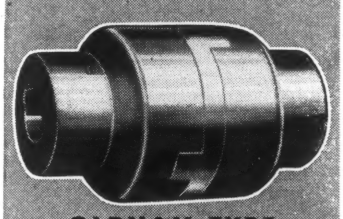
Popularly used sizes of most couplings are carried in stock and deliveries can be made quite promptly.

Shown here are the different types of *Flexible Couplings* which we can highly recommend to best meet the required needs.



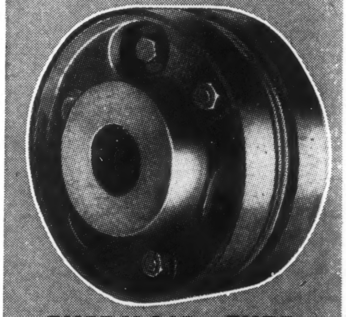
"C-W" RESILIENT TYPE

The most resilient coupling and best suited for extreme torsional vibration applications, but not recommended where there is frequent reversal of torque.



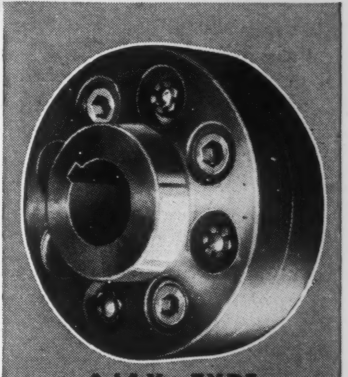
OLDHAM TYPE

Is recommended for speeds of 50 R.P.M. and below, and particularly adapted for installations where parallel misalignment errors are relatively large, and where angular misalignment errors are inappreciable.



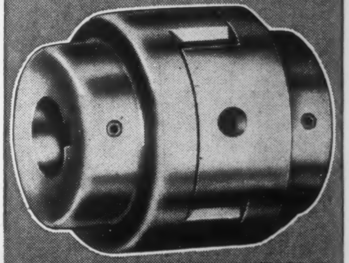
THERMOID TYPE

Designed and built to meet the demand of a more flexible and vibrationless coupling.



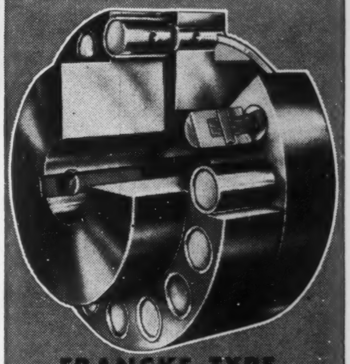
AJAX TYPE

Specially constructed to absorb and dampen shock, vibration, starting torque and momentary overload — by means of live rubber bushings.



PHILA. FLEXIBLE TYPE

Widely used for "general purpose" work. . . . Flexibility is obtained (without the use of flexible materials) by means of a floating center block of non-metallic material.



FRANCKE TYPE

Well suited where torsional resilience is required with all-metal construction.

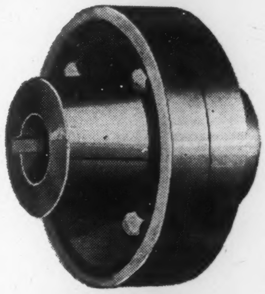
Philadelphia Couplings

SEND FOR CATALOG 150

and please use your Business Letterhead.

STEEL FLANGED TYPE →

A rigid coupling, and should not be used where both shafts are rigidly supported in bearings. Recommended for vertical drives such as agitators, where there is no lower bearing, or only one guide bearing.



Industrial Gears and Speed Reducers
LimiTorque Valve Controls

Philadelphia
GEAR WORKS INCORPORATED
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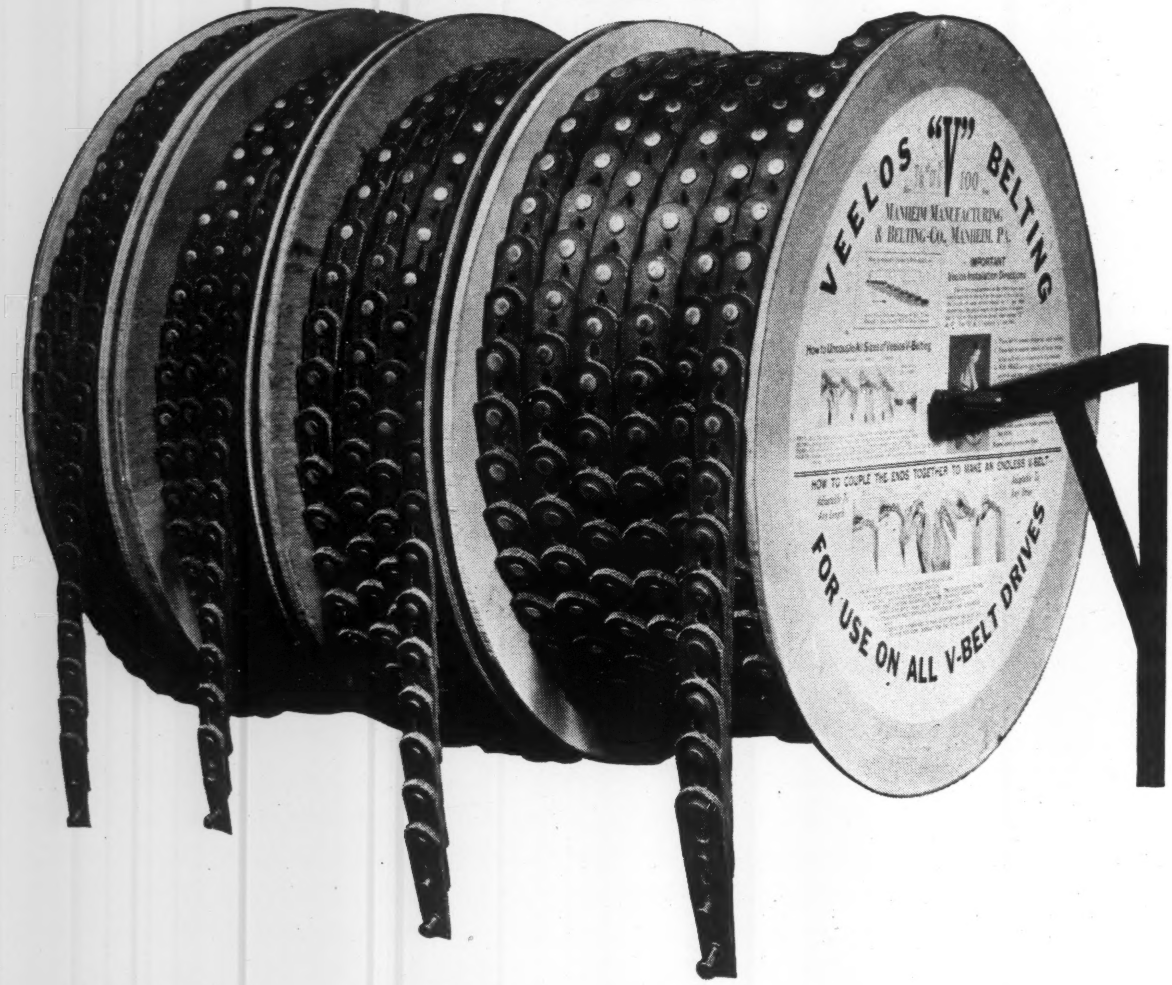
NEW YORK • PITTSBURGH • CHICAGO . . . IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Your COMPLETE V-Belt Inventory

can be as small (or smaller) than this!


VEELOS "V" BELTING
100
MANHEIM MANUFACTURING & BELTING CO. MANHEIM, PA.
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How to Uncouple All Sizes of Veelos V-Belting
HOW TO COUPLE THE ENDS TOGETHER TO MAKE AN ENDLESS V-BELT
FOR USE ON ALL V-BELT DRIVES

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Veelos is available in all standard sizes . . . fits all standard grooves — perfectly. Avail yourself of the real belt savings afforded by Veelos on reels.

Over 300 Veelos distributors and sales engineers located in principal cities to serve you.

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THE LINK
V-BELT

Adjustable to any Length
Adaptable to any Drive

MANHEIM MANUFACTURING & BELTING CO., MANHEIM, PA.

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In Detroit--
In Every
Modern City.

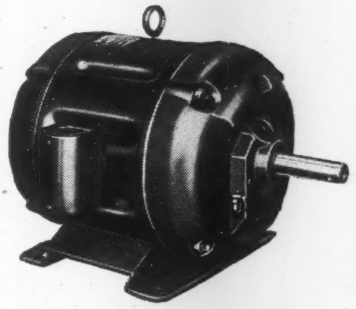
WAGNER *Quality* MOTORS

provide quiet, troublefree power for Heating, Ventilating and Air Conditioning Equipment

Cool and comfortable in summer . . . Warm and delightful in winter—Americans are becoming accustomed to conditions that make work and play more agreeable. Not only in large cities, but in villages too, air conditioning is a part of everyday life.

Heating, ventilating, and air conditioning has become a tremendous industry and Wagner engineers have played an important part in its development. Today, hundreds of thousands of Wagner Quality Motors are providing dependable, quiet, troublefree power. Users of Wagner motors also profit by our quick, convenient, nationwide service facilities.

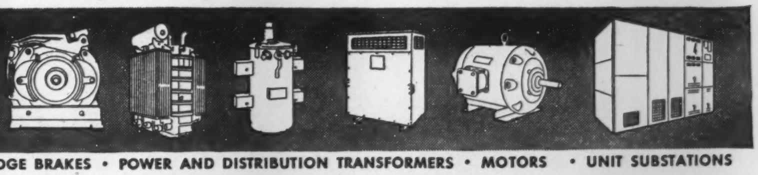
Twenty-nine branch offices, located in principal cities are ready to give you service. They can help you solve all of your motor problems. Write for Bulletin MU-185, addressing Wagner Electric Corporation, 6404 Plymouth Avenue, St. Louis 14, Mo.



Regardless of what your motor requirements may be—large motors . . . small motors . . . Wagner makes them all. The motor illustrated is typical of the Wagner line of polyphase and single phase motors. Choose a Wagner motor for your next installation.

Wagner Electric Corporation
EST. WE 1891

Consult Wagner Engineers on all Electric Motor Problems

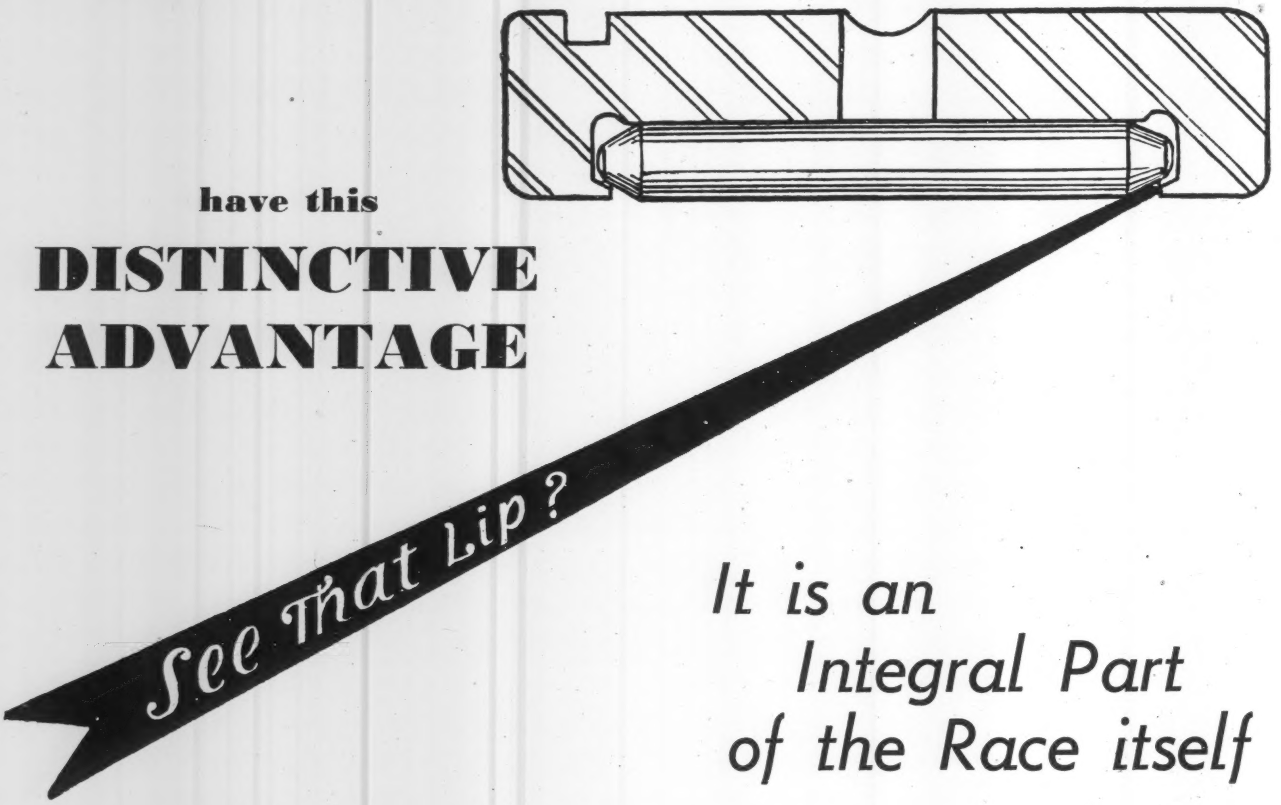


BRIDGE BRAKES • POWER AND DISTRIBUTION TRANSFORMERS • MOTORS • UNIT SUBSTATIONS

ELECTRICAL AND AUTOMOTIVE PRODUCTS

M47-5

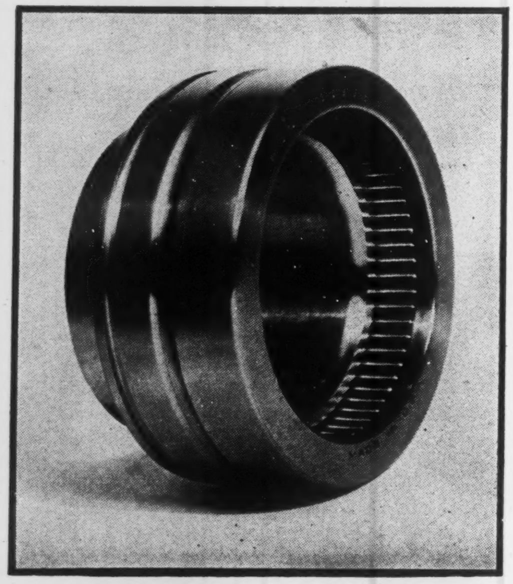
RBC CYCLOPS BEARINGS



have this

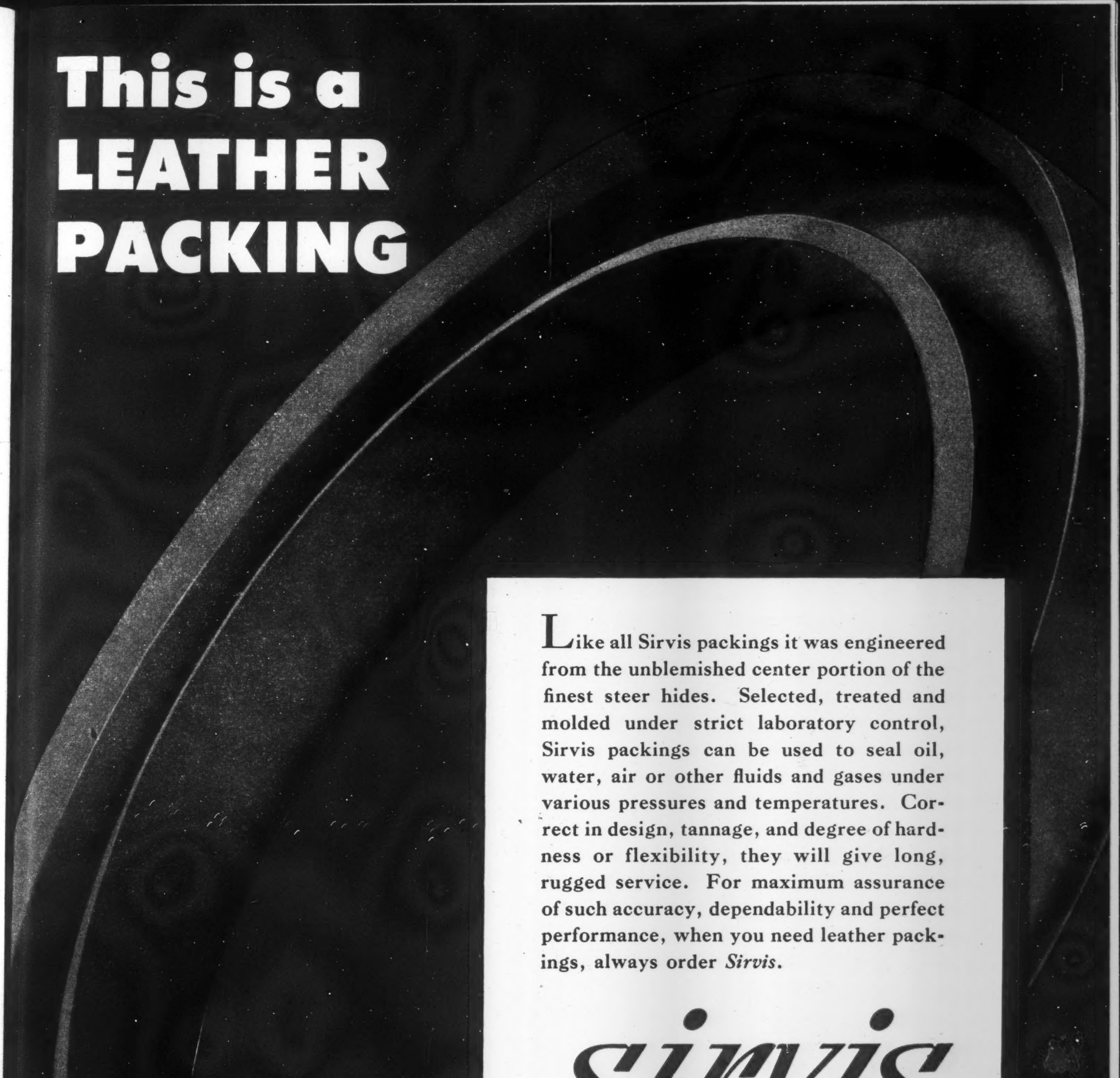
DISTINCTIVE ADVANTAGE

It is an Integral Part of the Race itself



Beside providing the firmest grip on the rollers, the CYCLOPS Design affords a broad, ground surface at each end of the raceway, giving a minimum of shaft clearance and a natural barrier against the intrusion of any foreign particles.

ROLLER BEARING CO. OF AMERICA
TRENTON, NEW JERSEY



This is a LEATHER PACKING

Like all Sirvis packings it was engineered from the unblemished center portion of the finest steer hides. Selected, treated and molded under strict laboratory control, Sirvis packings can be used to seal oil, water, air or other fluids and gases under various pressures and temperatures. Correct in design, tannage, and degree of hardness or flexibility, they will give long, rugged service. For maximum assurance of such accuracy, dependability and perfect performance, when you need leather packings, always order *Sirvis*.

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Products of

CHICAGO RAWHIDE MANUFACTURING CO.

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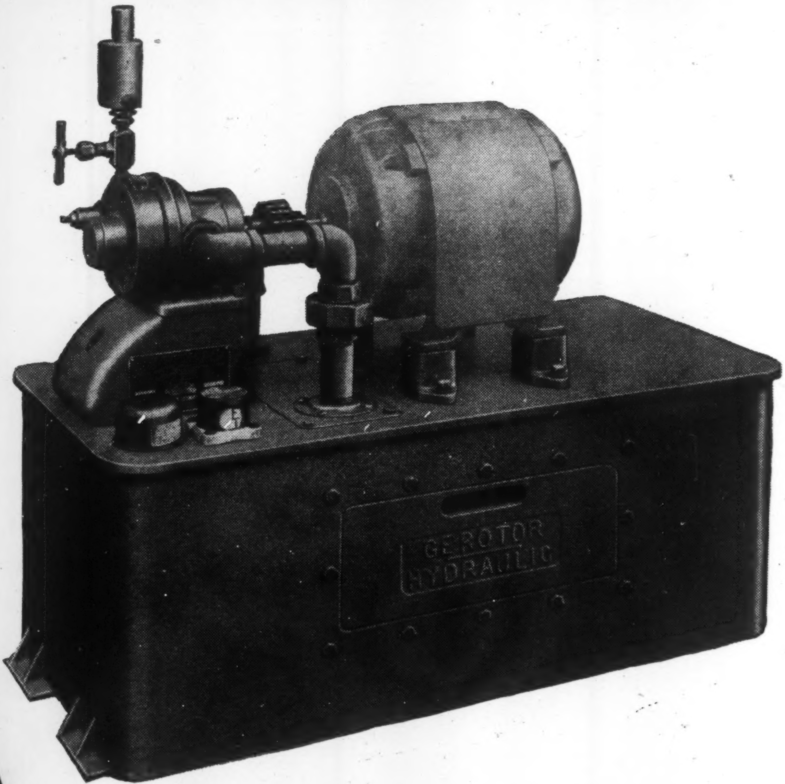
To accomplish the TASK of delivering a steady oil flow at continuous pressures up to 1000 p.s.i. (1200 in some pump sizes) . . .

FORCE

Your most effective FORCE is the unique Gerotor hydraulic pump, built into efficient pump units for either one or two oil circuits.

Like a naval task force, Gerotor hydraulic pump units are planned and equipped for their one specific mission. Complete with tank, relief valve, gauges, filter and coupling. . . for use with standard or special motors. Write for specifications!



GEROTOR HYDRAULIC

pump units

PUMPS · VALVES · CYLINDERS

GEROTOR MAY CORPORATION · BALTIMORE 3, MARYLAND

Smooth, Tough Formica *prevents Seconds!*

FORMICA
TRADE MARK REG. U.S. PAT. OFF.

In the textile industry one of the strongest reasons for using Formica parts in production equipment is the fact that its smooth, tight surfaces permits delicate fabrics to slide over it without ever snagging them—and the saving in seconds, so created, very quickly pays for the material.

Particularly in the production of fine knitted fabrics is that important, and that is why Formica hosiery carriers and Formica hosiery trays have had such an enthusiastic reception from mill managements.

So tough is the material that it resists shattering and splintering under the most severe use and maintains its original surface through a long life. It is non-absorbent and very quickly washed and cleaned.

Formica finds many other uses in mills of all kinds: Picker sticks, sweep sticks, loom box linings, separators, inspection table tops and many others.

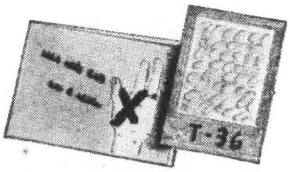
THE FORMICA INSULATION CO.
4648 SPRING GROVE AVENUE, CINCINNATI 32, OHIO

He was amazed
. . . at how little Fiberglas-Reinforced Plastics really cost*

Fiberglas T-36 mat is surprising lots of people. It lets designers take advantage of Fiberglas' unique combination of characteristics and at the same time, keeps costs down. It can be used in either high or low pressure laminating equipment . . . There are now fully developed production techniques which, in combination with T-36 mat, permit modern, high-speed production of reinforced plastics formed parts . . . If you are designing or manufacturing products which must have high tensile and impact strength, light weight, low moisture pickup and dimensional stability over a wide range of temperature and moisture changes, get complete information about Fiberglas-reinforced plastics.

SAMPLE OF T-36 MAT, which provides Fiberglas advantages at low cost, will be sent on request. Let us also send you a copy of the new booklet describing the various forms of Fiberglas plastics-reinforcing materials and illustrating the quantity production processes. Write Owens-Corning Fiberglas Corporation, Dept. 808, Toledo 1, Ohio. Branches in principal cities.

In Canada: Fiberglas Canada Ltd., Toronto 1, Ontario.



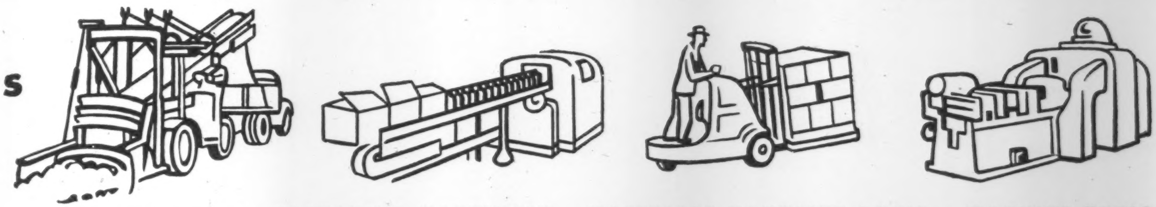
OWENS-CORNING
FIBERGLAS
T.M. REG. U.S. PAT. OFF.

FIBERS • MATS • CLOTHS

*FIBERGLAS is the trade name (Reg. U.S. Pat. Off.) of a variety of products made of or with glass fibers by Owens-Corning Fiberglas Corporation.

If you're designing or re-designing equipment

like this



ROAD GRADERS • PACKAGING MACHINERY • MATERIALS HANDLING EQUIP. • MACHINE TOOLS

GET effective speed and feed controls from

Standard Hydraulic Equipment

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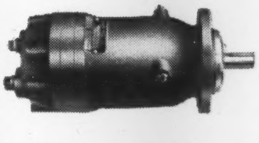
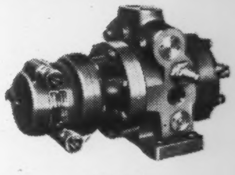
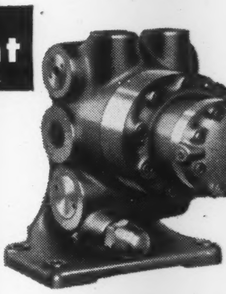


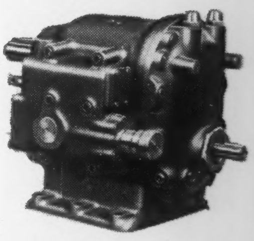
FLUID MOTORS



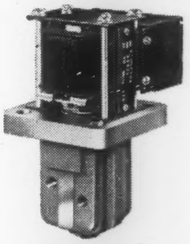
PUMPS



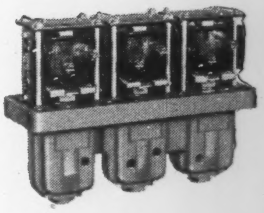
CLAMPING PUMPS



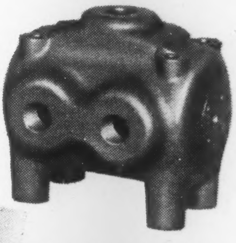
TRANSMISSIONS



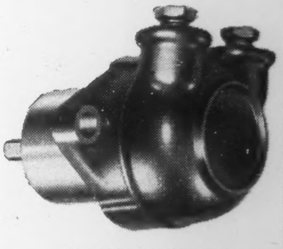
SINGLE SOLENOID VALVES



TRIPLE SOLENOID VALVES



FOUR-WAY VALVES



LUBRICATING PUMPS

Yes, many designers have found better solutions to their hydraulic design problems with these standard Sundstrand elements. It's merely a simple matter of designing an efficient circuit and adapting the proper combinations of these elements to the circuit. Our hydraulic application engineers will be glad to assist you with the circuit design. Applying the proper elements will result in smooth and effective speed and feed controls.

So, if you're designing new equipment or re-designing present models, call in a Sundstrand hydraulic application engineer. There is no obligation for this service.

MORE FREE DATA is included in this set of up-to-date bulletins. Write for your copies today. Ask for bulletins No. M 16

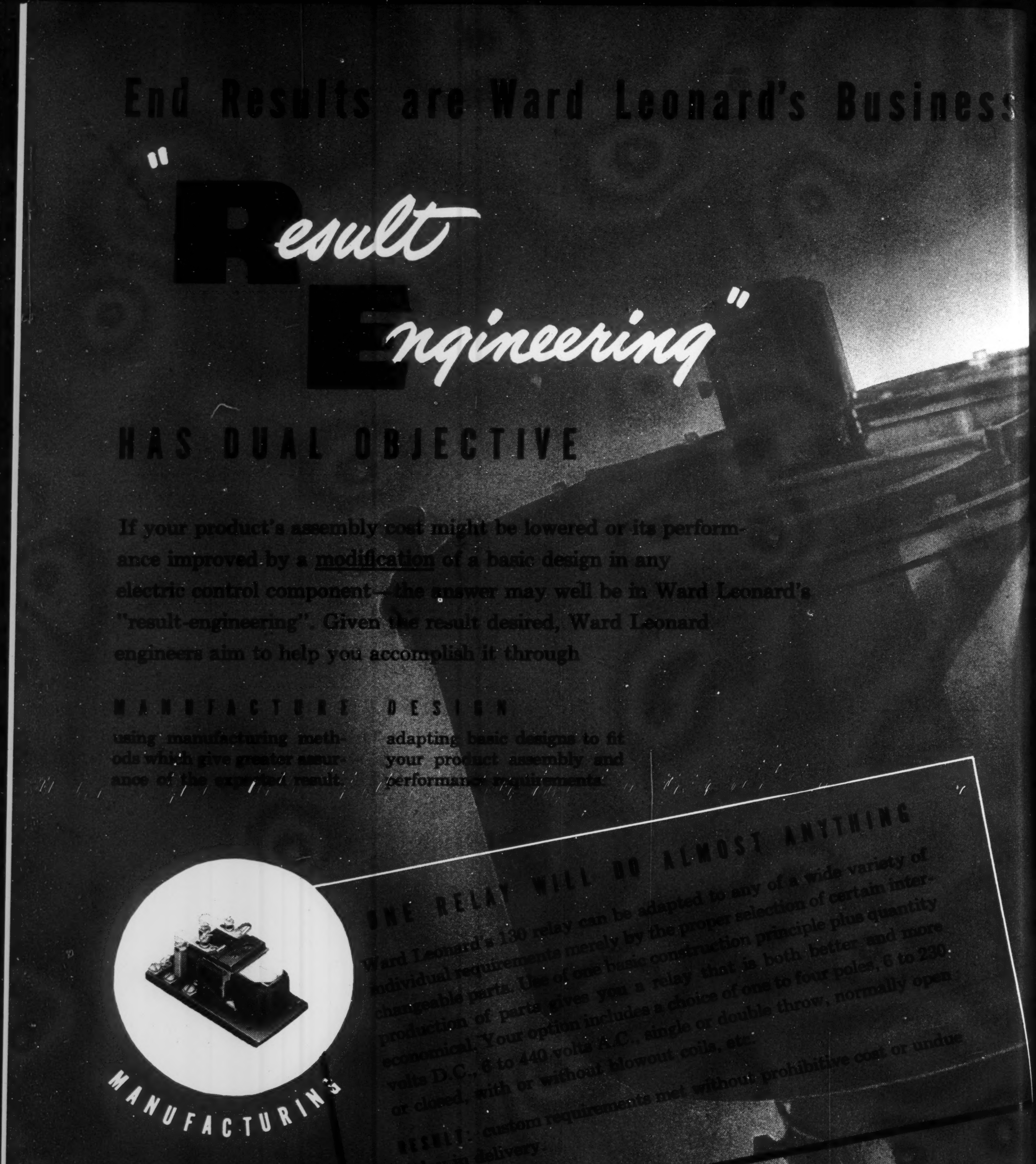
Sundstrand
Hydraulic Equipment
SUNDSTRAND
OIL POWER TRANSMISSION
for Variable Speeds
SUNDSTRAND
OIL POWER
FLUID MOTORS

SUNDSTRAND MACHINE TOOL CO. ROCKFORD, ILLINOIS U.S.A.

SUNDSTRAND PUMP DIVISION

2559 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS



End Results are Ward Leonard's Business

"Result Engineering"

HAS DUAL OBJECTIVE

If your product's assembly cost might be lowered or its performance improved by a modification of a basic design in any electric control component—the answer may well be in Ward Leonard's "result-engineering". Given the result desired, Ward Leonard engineers aim to help you accomplish it through

MANUFACTURE using manufacturing methods which give greater assurance of the expected result.

DESIGN adapting basic designs to fit your product assembly and performance requirements.

ONE RELAY WILL DO ALMOST ANYTHING

Ward Leonard's 130 relay can be adapted to any of a wide variety of individual requirements merely by the proper selection of certain interchangeable parts. Use of one basic construction principle plus quantity production of parts gives you a relay that is both better and more economical. Your option includes a choice of one to four poles, 6 to 230 volts D.C., 6 to 440 volts A.C., single or double throw, normally open or closed, with or without blowout coils, etc.

RESULT: custom requirements met without prohibitive cost or undue delay in delivery.

WARD LEONARD ELECTRIC CO.

Where Basic Designs in Electric Controls

THE CENTRIFUGE WON'T SPILL

Trouble had been experienced due to carelessness in stopping a centrifuge. Instead of turning the speed regulating rheostat back to the "off" position, the operator would open a line switch or pull a plug. Upon resuming the "spin", the abrupt start might break the specimen holder, spill the contents or seriously overload the rheostat.

Ward Leonard, asked to furnish rheostats, recommended interlocking a relay with the rheostat contact arm and a standard 3-wire low-voltage protection relay.

RESULT: the centrifuge cannot be operated until the rheostat is returned to the starting position.

DESIGN

BLUE MEANS

"Result Engineering"

In resistors, rheostats, relays and other electric controls, the distinctive blue identifies Ward Leonard "result-engineering".

FREE BULLETINS on "Result-Engineered" Relays

(Please request on business letterhead, mentioning your title)

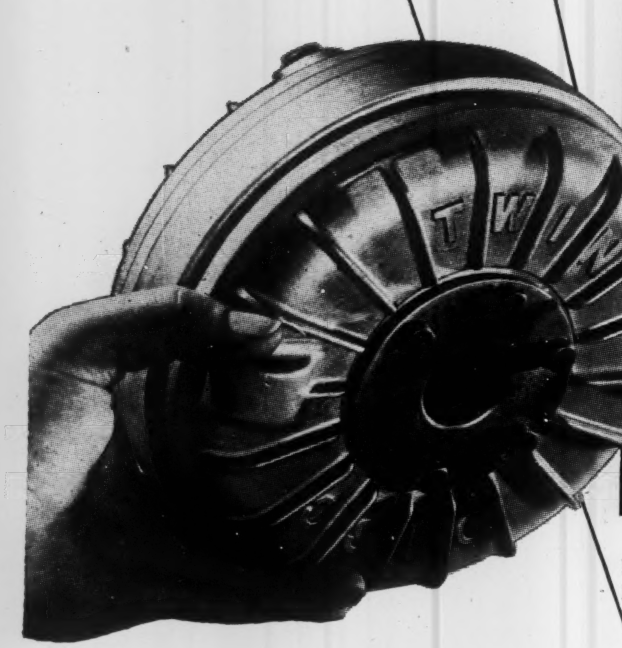
WARD LEONARD ELECTRIC CO.
MOUNT VERNON, NEW YORK
Offices in principal cities of U. S. and Canada

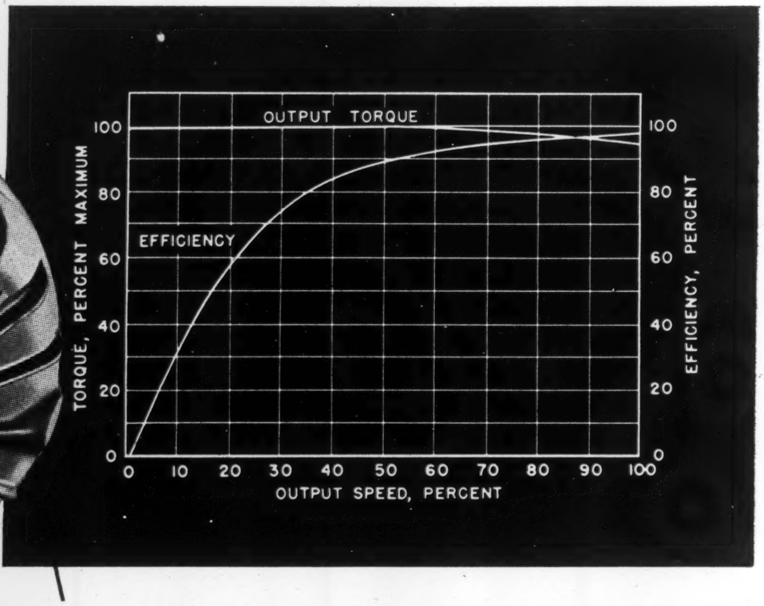
W
WARD LEONARD
L

RESISTORS • RHEOSTATS
RELAYS • CONTROL DEVICES

are "Result-Engineered" for You

Full Torque Delivery



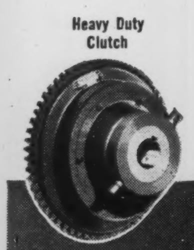


Full engine torque is available at all output speeds from zero to 100 per cent. Normal operation follows at a coupling efficiency of 95 to 97 per cent.

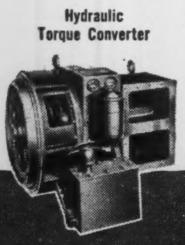
Full torque delivery at all output speeds is one of the most important characteristics of the new Twin Disc Small Hydraulic Coupling. When the load requires maximum torque, causing a reduction in the speed of the coupling output shaft—as when overcoming inertia on an overhead crane, or speeding up a small, powered vehicle—the hydraulic coupling permits the engine or motor to maintain higher speed, thereby transmitting higher torque as required for maximum acceleration of the load. In this manner, full torque output is assured under all conditions of operation.

Six sizes of Twin Disc Small Hydraulic Couplings, ranging from 7.4″ to 12.2″, are available for application to electric motors or internal combustion engines rated from 1 to 25 hp. For complete information, write the Twin Disc Clutch Company, Rockford, Ill., for a copy of the "Small Hydraulic Coupling Issue" of Production Road which illustrates tested applications of the new unit. Twin Disc Clutch Company, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

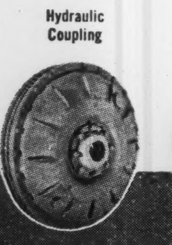
Heavy Duty Clutch



Hydraulic Torque Converter

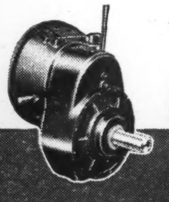


Hydraulic Coupling

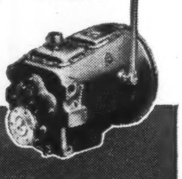


TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

Reduction Gear



Marine Gear

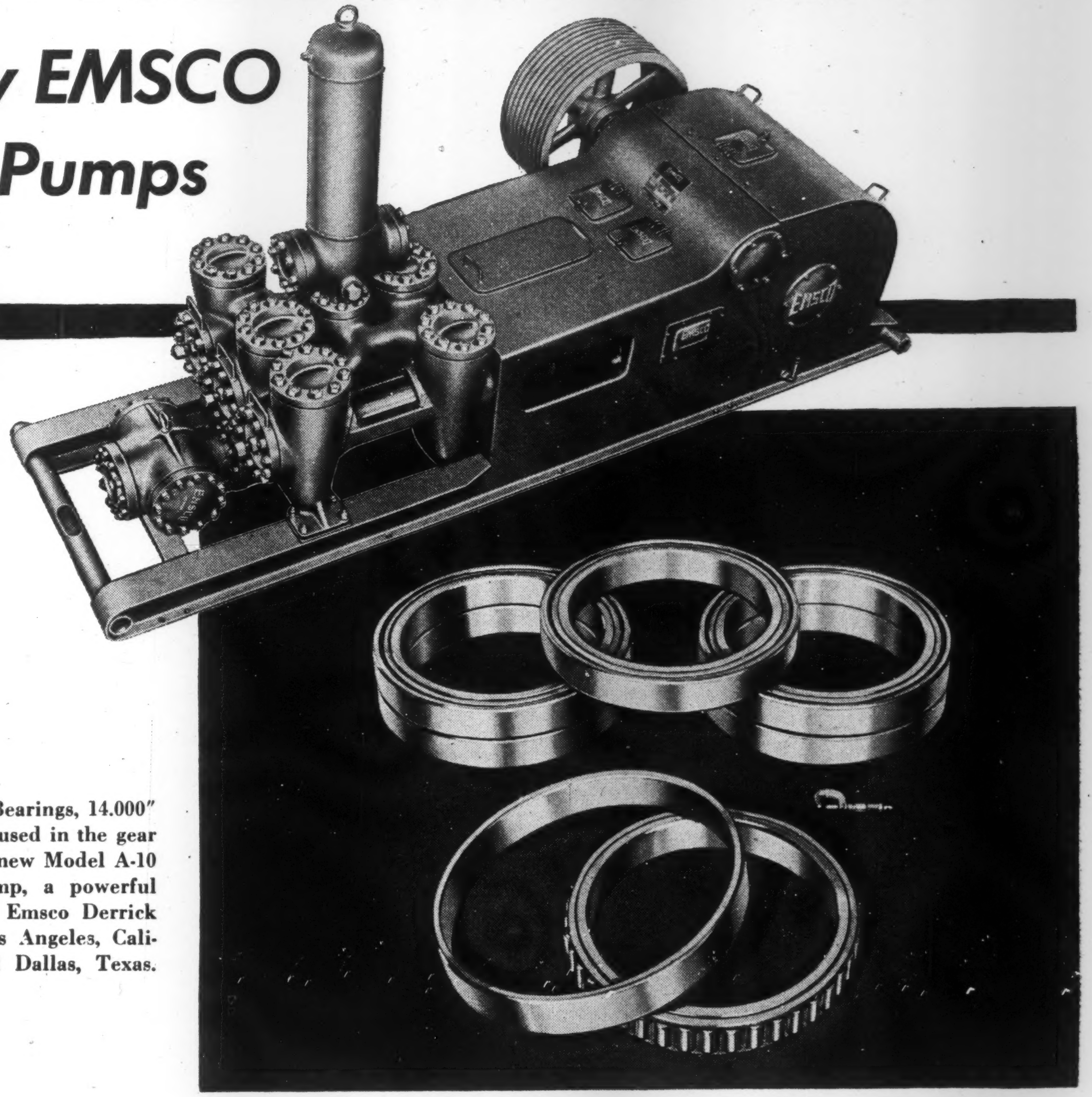


SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

Wichita City Libra

KAYDON BEARINGS OK'd

for New EMSCO Triplex Pumps



KAYDON Radial Roller Bearings, 14.000″ x 18.000″ x 2.500″ are used in the gear reduction unit of the new Model A-10 EMSCO Triplex Pump, a powerful slush pump made by Emsco Derrick & Equipment Co., Los Angeles, California; Houston and Dallas, Texas.

Oil field operators know EMSCO Slush Pumps for their fine engineering design, that results in big savings in weight, higher horsepower capacity per unit of weight, greater strength, and dependable performance.

KAYDON Bearings, precision-built and rugged, fit right into the sound engineering policies that have made modern EMSCO machinery so successful.

Similarly, in other fields of heavy-duty machinery, **KAYDON** Bearings are helping designers add outstanding advantages. Huge precision grinders, steel mill equipment, paper mill machinery, road-building units, excavators, hoists, crushers, bending machines and other heavy-duty equipment are serving industry better because of **KAYDON** Bearings.

* * *

Capacity now available for all types and sizes of **KAYDON** Bearings . . . standard or special. A confidential discussion of your problems may point the way to opportunities through use of **KAYDON** Bearings.

KAYDON *Types of Standard or Special Bearings:*
Spherical Roller • Taper Roller • Ball Radial
Ball Thrust • Roller Radial • Roller Thrust

THE KAYDON ENGINEERING CORP., MUSKEGON, MICH.

All types of Ball and Roller Bearings 4″ bore to 120″ outside diameter

116% MORE POWER PER POUND .

Up to 134% more starting torque per pound of motor . . . with as much as 116% more maximum torque per pound! As much as one third smaller . . . yet stronger mechanically AND electrically than any previous Westinghouse induction motor!

That's the achievement represented in the Westinghouse Life-Line—the biggest single advance in fundamental motor design in 58 years.

It wraps up in one solid steel-encased package, user preferences formerly obtainable only as custom-built features, if at all.

It makes available to industry, in a standard line of motors, improvements perfected for special wartime requirements.

Life-Line Motors are now in production at the new Buffalo Westinghouse Motor Plant, in frame sizes representing the popular demand of induction motor ratings. Check your nearest Westinghouse office for availability, or write Westinghouse Electric Corporation, P. O. Box 2025, Buffalo 5, N. Y.

J-21408

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Life-Line motors

up to ⅓ less space!
Features and improvements demanded most by users —
ALL WRAPPED IN A SINGLE PACKAGE!

ALL-STEEL PROTECTION

All frames, feet and brackets are HEAVY STEEL. Stators are far stronger . . . new core locking device eliminates rivets.

NO LUBRICATION FOR 5 YEARS

No greasing is needed for AT LEAST FIVE YEARS. Bearings are pre-lubricated . . . sealed against dirt and moisture.

NEW QUIET SMOOTHNESS

Life-Lines cut vibration and noise to new low limits for standard motors . . . satisfy many "special motor" needs.

LESS SPACE PER HP

Life-Line Motors occupy less space per hp than any other standard motor . . . are easier to build into machines and install in cramped quarters.

IMPROVED WINDINGS

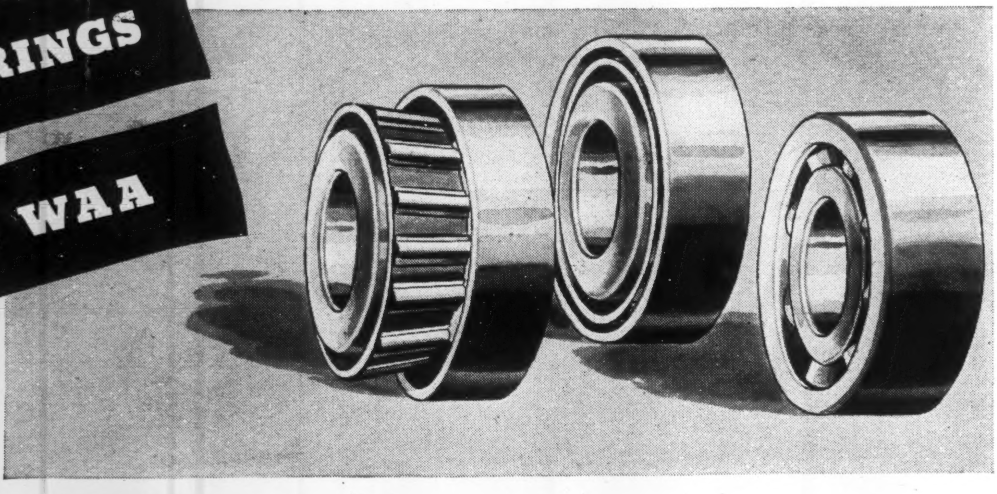
New insulating materials . . . coil winding techniques . . . stator slot designs . . . give new record-setting protection against electrical failures.

NEW SLEEK LINES

The Life-Line has sleek lines . . . a smooth finish . . . discourages dust and dirt accumulations . . . harmonizes with modern machine and tool design.

START ROLLING ON BEARINGS FROM WAA

SET YOUR OWN PRICE IN SEALED BID SALES



Get your bearings from the $20,000,000 stock now being sold by WAA. Friction and anti-friction bearings and components in all sizes and types are included in this stock. Many sizes are available in production-run quantities. Set your own price on what you need and submit your bid. Get all pertinent information from your nearest WAA Regional Office—go there to make your own inspection.

OFFICE OF GENERAL DISPOSAL

WAR ASSETS ADMINISTRATION

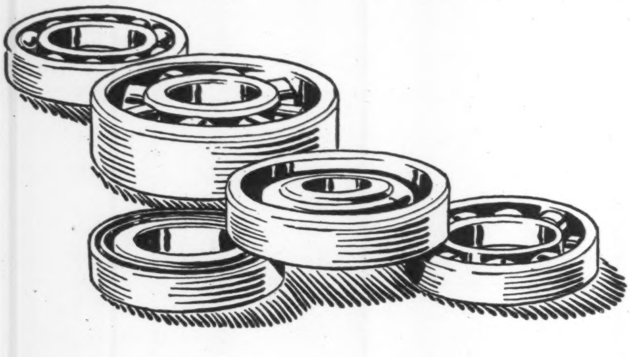
GOVERNMENT WAA SURPLUS

Offices located at: Atlanta • Birmingham • Boston • Charlotte • Chicago
Cincinnati • Cleveland • Dallas • Denver • Detroit • Fort Worth • Helena • Houston
Jacksonville • Kansas City, Mo. • Little Rock • Los Angeles • Louisville • Minneapolis
Nashville • New Orleans • New York • Omaha • Philadelphia • Portland, Ore. • Richmond
Salt Lake City • St. Louis • San Antonio • San Francisco • Seattle • Spokane • Tulsa

1081

Sales of bearings will be held at frequent intervals. To receive information on future sales, write, wire or phone the Regional Offices listed below asking that your name be placed on their mailing lists

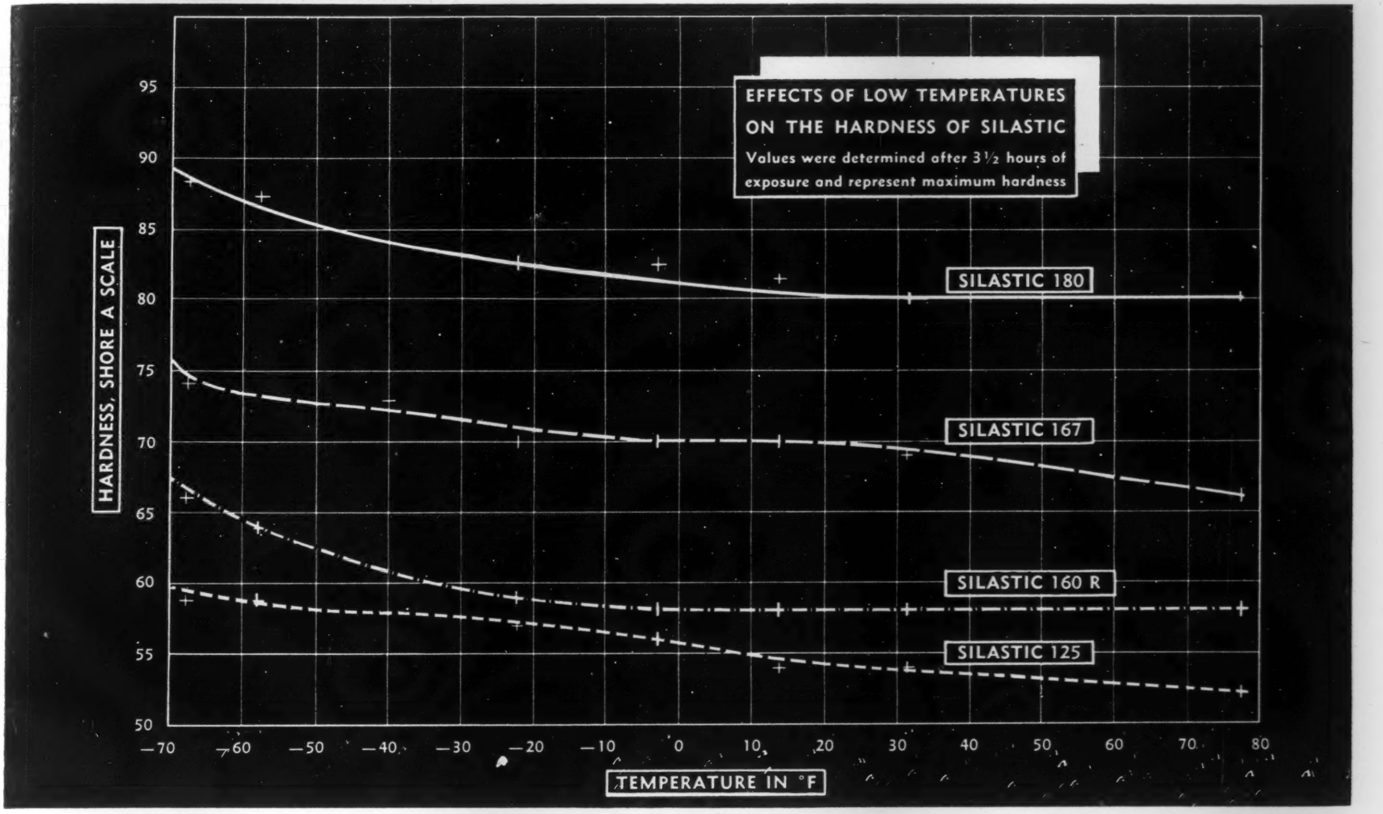
BOSTON • CINCINNATI • CHICAGO • ST. LOUIS
CLEVELAND • LOS ANGELES • NEW YORK



DC
DOW CORNING
SILICONES

SILASTIC*
VARNISHES
RESINS
FLUIDS
GREASES

In Arctic Cold or Oven Heat...



EFFECTS OF LOW TEMPERATURES ON THE HARDNESS OF SILASTIC

Values were determined after 3½ hours of exposure and represent maximum hardness

SILASTIC STAYS ELASTIC!

Silastic remains flexible at lower temperatures than any other rubber-like material, and still keeps its resiliency at temperatures far above the limits of any natural or synthetic rubbers. The graph reproduced above shows how little the various kinds of Silastic increase in hardness at temperatures down to −70°F.

In every case, the values given in this graph are the maximum durometer readings obtainable at the test temperature. Even more important in many low temperature applications is the fact that these same hardness values will be obtained even after the test samples have been exposed for an indefinitely long period of time at 300-350°F.

Brittle points are also of primary importance to anyone seeking a rubber-like material useful at both extremely low and high temperatures. The brittle points of the various kinds of Silastic were determined by holding the samples at progressively lower temperatures for 5 hours.

Brittle point values ranging from −70°F. to −100°F. are given in the table at the right.

For information about Silastic as a gasketing material write for leaflet No. B 13-1.

DOW CORNING CORPORATION · MIDLAND, MICHIGAN
New York • Chicago • Cleveland • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

BRITTLE POINTS OF SILASTIC
(ASTM D 736-43T)

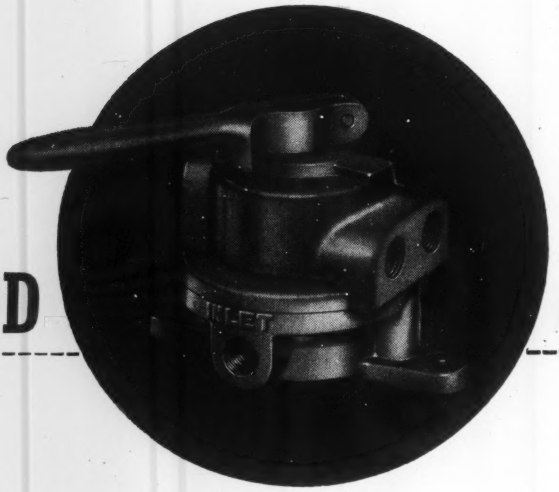
after 5 hours exposure to test temperature

Silastic	°F.	°C.
120	−90 to −100	−68 to −73
125	−90 to −100	−68 to −73
150	−70	−57
160	−70 to −90	−57 to −68
160 Red	−90	−68
167	−80	−62
180	−90	−68
181	−80	−62

*TRADE MARK, DOW CORNING CORPORATION

Dow Corning
FIRST IN SILICONES

a GOOD air cylinder . . .



deserves a GOOD operating valve

No need to take chances

Use valves you can **count** on.
The Hannifin Packless Valve
Design **insures** year after year of
maintenance free service.

- *48 low cost models to choose from.*

You obtain maximum service from
Hannifin Air Cylinders

- *10 sizes 1" to 12" bore*
- *6 basic mounting styles*
- *Piston stroke as specified*

Request bulletin 57-A.

HANNIFIN
CORPORATION
Chicago 24

How long do you expect a Limit Switch to last?

SNAP-LOCK
SWITCH
No. 16D-1200
THE NATIONAL ACME CO.
CLEVELAND, OHIO
MADE IN U.S.A.
PATENTED

Perhaps we do build Snap-Lock Limit Switches better than they need to be. But remember that they were first built for use on our own machines, where we were willing to pay a little extra for guaranteed performance.

The investment proved a good one for us. It gave us complete assurance that users of our machines need not fear switch failure—for the life of the machine. And it is also proving a good switch for other builders of machine tools, 80% of whom now use Snap-Locks.

If you want the limit switch performance of your machine insured, use the one Limit Switch—Snap-Lock—built *by* machine tool builders *for* machine tool builders.

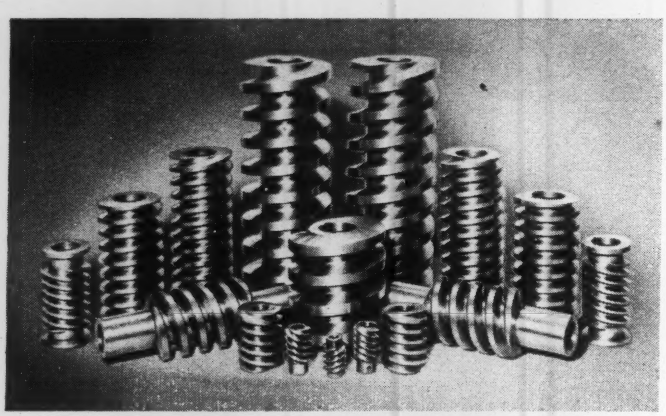
Bulletin EM-42 gives full details.

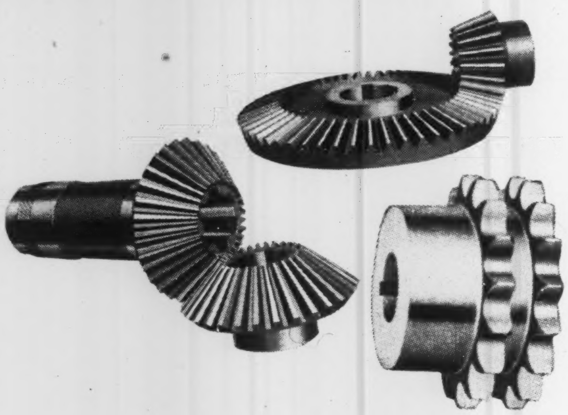
ELECTRICAL MANUFACTURING DIVISION

The NATIONAL ACME CO.

170 EAST 131st STREET • CLEVELAND 8, OHIO

Acme-Gridley Bar and Chucking Automatics: 1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • The Chronolog • Limit, Motor Starter and Control Station Switches • Solenoids Centrifuges • Contract Manufacturing





You'll get *smoother,* more *efficient* OPERATION FOR YOUR PRODUCT WITH ADAMS GEARS

"Tailor-made" gears designed especially for the job provide the opportunity to improve the performance standards of your product. Built for the product, they often simplify assembly and reduce production costs, too. Here at Adams we are specialists in making gears that meet your specifications exactly. Care and control exercised at every stage in their manufacture assure smooth, efficient power transmission. Write for further details. THE ADAMS COMPANY, 1942 Tower St., Dubuque, Iowa.

the ADAMS compa
Dubuque, Iowa, U. S. A.
ESTABLISHED 1883
GEARS
FINE GEARS MADE TO YOUR SPECIFICATIONS

MAKE MORE MONEY BY REDESIGNING FOR RETAINING RINGS

The illustration shows another wise use of retaining rings on Delta Drill Presses.

Hundreds of machines and products can be designed to use these inexpensive, yet efficient, artificial shoulders. They save money and metal.

When so many costs are rising you can keep up your margin of profit by smart designing. Don't cut down shafts to make shoulders—it's useless waste. Groove your shafts and housings and use these high grade steel rings.

Write us today for descriptive folders; let our engineers consult with yours.

THE NATIONAL LOCK WASHER CO.
Newark 5, New Jersey **Milwaukee 2, Wisconsin**

KUX

MODEL K

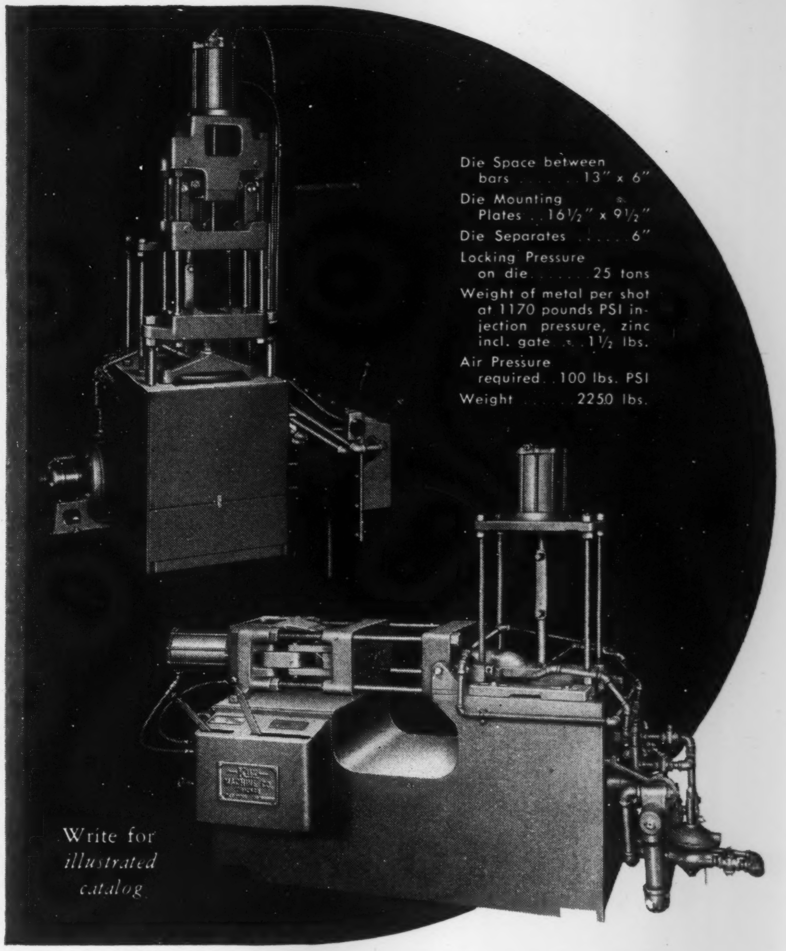
THE MIGHTY MIDGET OF DIE CASTING MACHINES

. . . is the safest, most highly productive small die casting machine on the market! Available in horizontal or vertical center shot models, die castings weighing up to 1½ pounds in zinc are produced under high injection pressures, insuring quality, castings with minimum porosity.

Compare these features:

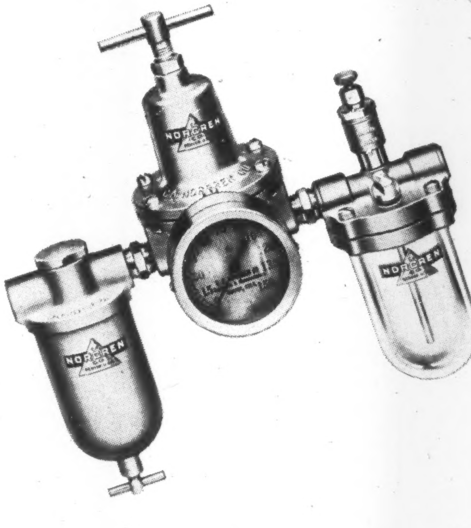
Center shot operation with floating nozzle always in seated contact with the die and one-piece gooseneck. Speed and power obtained by use of an air compressor to operate opening and closing of die, and metal injection plunger. Double safety lock, mechanical-electrical, prevents metal shot while die is in open position. Double toggle mechanism locking in two directions absorbs all locking pressures, operates on all four corners of die plate. Built-in ejector plate for positive ejection. Self-contained gas or oil firing unit.

KUX MACHINE COMPANY
3928 W. HARRISON ST. CHICAGO 24, ILL.



Die Space between bars	13″ x 6″
Die Mounting Plates	16½″ x 9½″
Die Separates	6″
Locking Pressure on die	25 tons
Weight of metal per shot at 1170 pounds PSI injection pressure, zinc incl. gate	1½ lbs.
Air Pressure required	100 lbs. PSI
Weight	2250 lbs.

Write for illustrated catalog



LICK AIR-LINE PROBLEMS

with Norgren Lubro-Control Units

Increase efficiency and dependability of production line air tools and cylinders.

Compact, assembly of filter, regulator and lubricator. Performance proved. Automatic. Provides three top-notch protection features:

ABSOLUTE CLEANING
POSITIVE CONTROL
CONTINUOUS LUBRICATION

FILTER stops dirt, rust and pipe scale; catches oil emulsion and moisture.

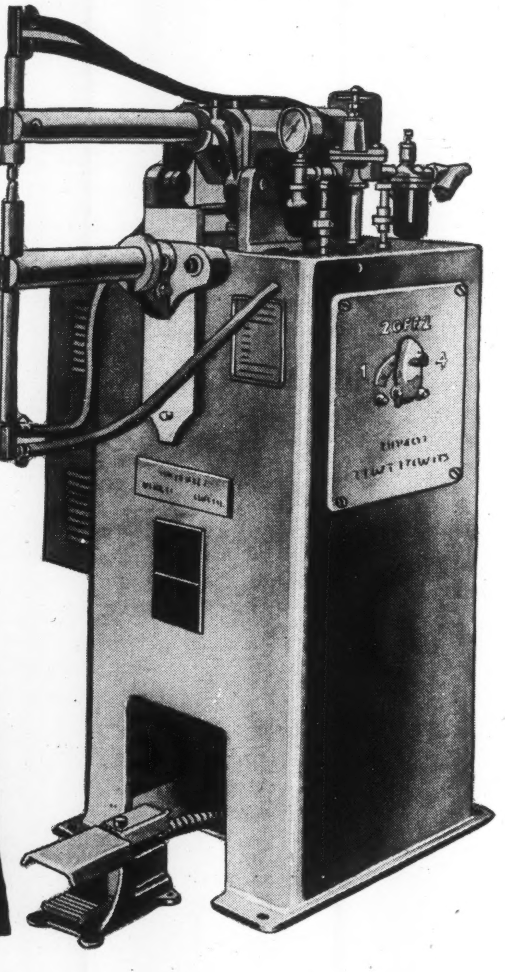
REGULATOR controls variable air line pressures.

LUBRICATOR oils the air that drives the tool or cylinder. Smoother performance during operations. Full protection against rust and corrosion while tool is idle.

Write for catalog 400. C. A. Norgren Co., 222 Santa Fe Drive, Denver 9, Colorado.

Norgren

as low as 40% of market



SURPLUS RESISTANCE WELDERS

RESISTANCE SPOT WELDERS:

TYPES AVAILABLE: Rocker Arm, Press, Portable or Gun, and some Multi-Electrode types, in well-known makes. Motor, air, hydraulic or manual operation; rated from 10 to 400 KVA; 220-440 volt, 60 cycle, single phase; throat depths 8" to 48"; synchronous and non-synchronous.

CONDITION: Mostly used, some unused.

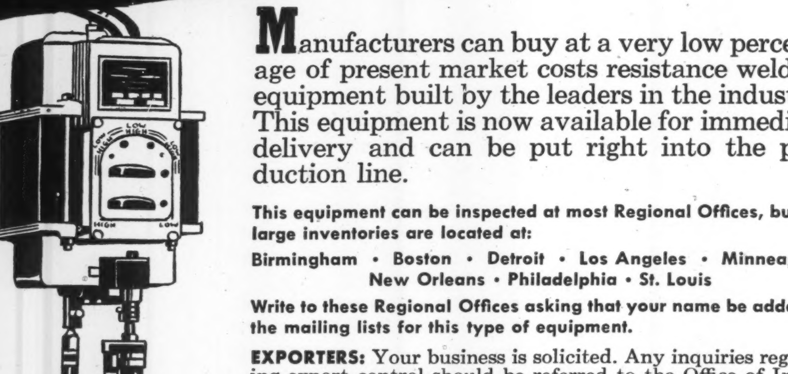
RESISTANCE SEAM WELDERS:

TYPES AVAILABLE: Longitudinal, Circular, and Universal; also Multi-Electrode types.

RANGE OF SPECIFICATIONS AND CONDITION: Same as Spot Welders.

OTHER TYPES: Butt and Flash resistance welders; and Stored Energy Spot Welders up to 50 KW and 48" throat depth (also a few machines of greater capacity).

All welders are sold under existing priority regulations. VETERANS OF WORLD WAR II are invited to be certified at the War Assets Administration Certifying Office serving their area, and then to purchase the materials offered herein.



Manufacturers can buy at a very low percentage of present market costs resistance welding equipment built by the leaders in the industry. This equipment is now available for immediate delivery and can be put right into the production line.

This equipment can be inspected at most Regional Offices, but the large inventories are located at:

Birmingham • Boston • Detroit • Los Angeles • Minneapolis
New Orleans • Philadelphia • St. Louis

Write to these Regional Offices asking that your name be added to the mailing lists for this type of equipment.

EXPORTERS: Your business is solicited. Any inquiries regarding export control should be referred to the Office of International Trade, Department of Commerce, Washington, D. C.

OFFICE OF GENERAL DISPOSAL

WAR ASSETS ADMINISTRATION

Offices located at: Atlanta • Birmingham • Boston • Charlotte • Chicago
Cincinnati • Cleveland • Dallas • Denver • Detroit • Fort Worth • Helena • Houston
Jacksonville • Kansas City, Mo. • Little Rock • Los Angeles • Louisville • Minneapolis
Nashville • New Orleans • New York • Omaha • Philadelphia • Portland, Ore. • Richmond
Salt Lake City • St. Louis • San Antonio • San Francisco • Seattle • Spokane • Tulsa

1047

*Specified Tolerance ± *, Test Accuracy ± ?*

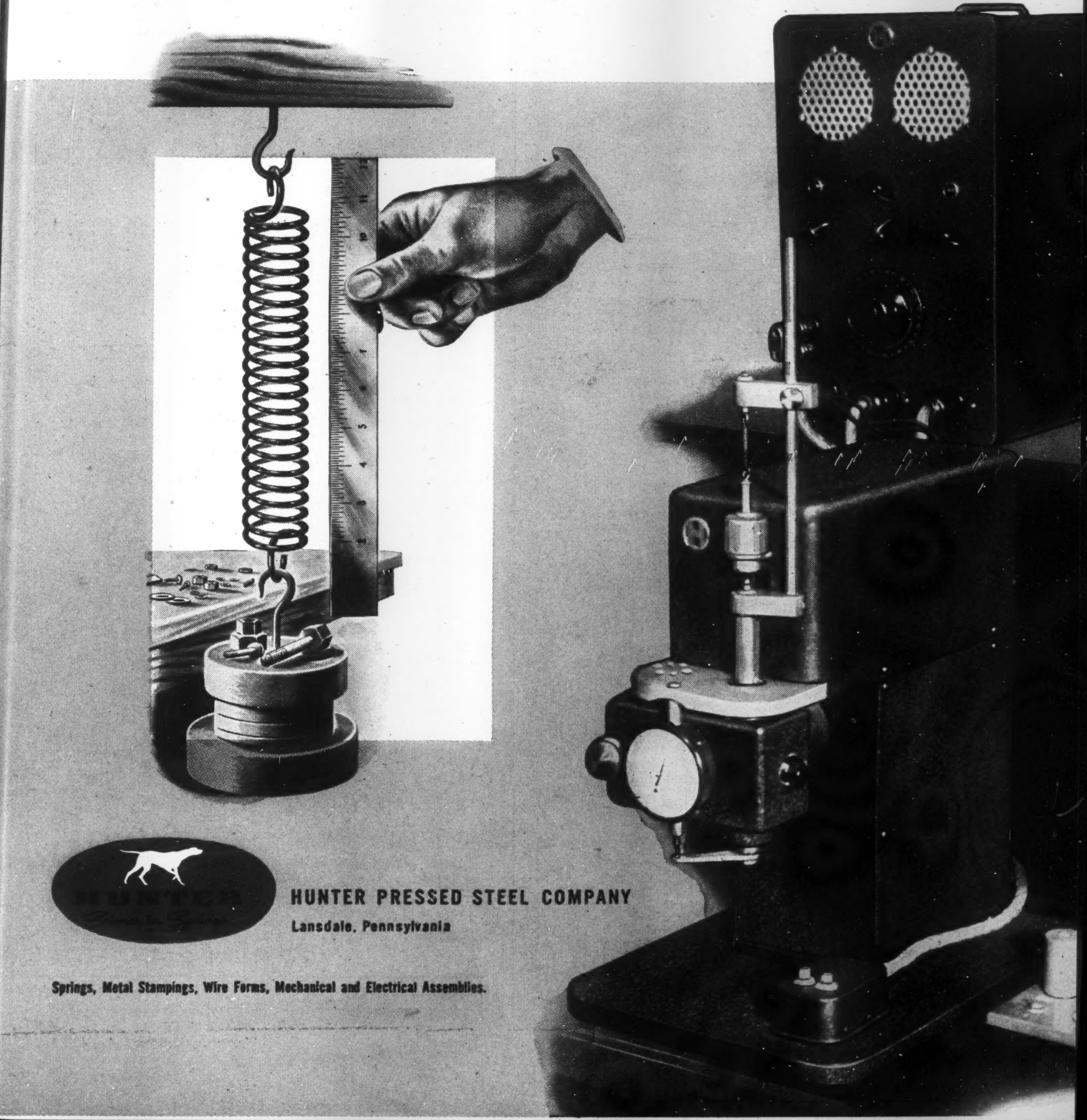
It is comparatively easy to lay down close tolerance specifications for springs. But can you tell you are getting them?

Strange as it may seem, springs are often ordered to tolerances beyond the purchaser's capacity or means for inspection.

Certain types of inspection equipment are accurate but not nearly fast enough for checking large quantities of springs. Others are *neither* fast nor accurate. And it is a matter of record that some plants use equipment which has all the appearance, the sensitivity and the speed of fish scales . . . and old-fashioned fish scales at that.

If you must insist on springs with close tolerances, make sure you provide your inspectors with equipment for testing them quickly and adequately. Or order springs from Hunter where you get the tolerance you pay for . . . guaranteed by inspection devices of amazing accuracy and speed.

*Often next to nothing.



HUNTER
Chosen for Springs

HUNTER PRESSED STEEL COMPANY
Lansdale, Pennsylvania

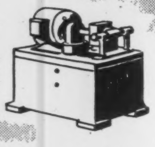
Springs, Metal Stampings, Wire Forms, Mechanical and Electrical Assemblies.

"Why WESTERN FELT?

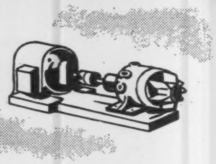
I'll Tell You Why..."

It's resilient—prevents the transmission of destructive vibration to delicate machinery by absorbing the shock.

It's versatile—is widely used as gaskets, pads, washers, weatherstripping, thermacoustic insulation . . . in smallest precision instruments to massive engines.



It's firm—neither loses its shape nor frays . . . can be cut to tolerances measured by thousandths of an inch.



It's long-lived—incorporates flexibility, compressibility, and resistance to water, age, heat, oil, alcohol, sound.

Right! And don't forget to mention that Western Felt has 47 years of experience in the design and manufacture of superior felt shapes—that Western engineers are anxious to help you solve any problem involving the possible use of felt. Write "Western" today.

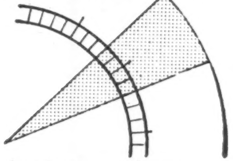
Acadia Synthetic Products Division, WESTERN FELT WORKS, Processors of Synthetic Rubbers—Sheets, Extrusions, Molded Parts.

WESTERN FELT WORKS

4035-4117 Ogden Avenue, Chicago 23, Illinois
Branches in All Principal Cities
LARGEST INDEPENDENT MANUFACTURERS AND CUTTERS OF WOOL, HAIR, AND JUTE FELTS

INVESTIGATE

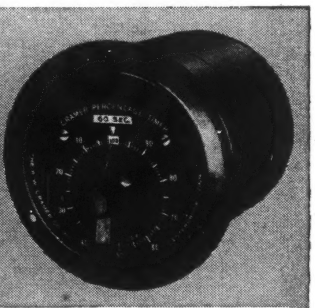
CONTROL BY "TIME-PERCENTAGE"



MORE DEPENDABLE
MORE ACCURATE
MORE FLEXIBLE

A typical example is the operation of electric ovens where time-percentage regulation of current input permits extremely close control of temperature, eliminating the "lag" inevitable with thermostatic devices. Same principle gives equally good results in regulating proportioned flow of materials or liquids and in many other operations.

Cramer
AUTOMATIC PRECISION
PERCENTAGE TIMER



Easy to set, easy to read, and designed to harmonize with other standard instruments in group panel mountings. Graduations may be in percentage of time or directly translated to feet-per-minute, gallons-per-hour, degrees of temperature, etc.,

DISTINCTIVE FEATURES

Simple, rugged and compact precision instruments designed to "take it" day in and day out in busy plants. Adjustable from the front and while running. Dials clear and easy to read. Calibrations and ranges widely adaptable to specific process requirements. Timers will repeat within 0.25% of any given setting. Specially designed motors and operating switch mechanisms rated for continuous service and completely enclosed in dust proof bakelite housing. One of many Cramer Time Control Devices ready to help you eliminate costly weak links in the chain of production control. Our broad experience in this field may be very helpful to you. Write us your needs . . . ask for our literature, NOW.

THE R. W. CRAMER COMPANY, INC.
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A PART OF THE
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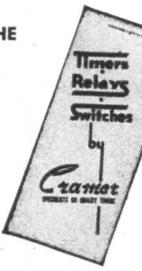

Cramer

SPECIALISTS IN **TIME**
AS A FACTOR OF **CONTROL**

INTERVAL : DELAY : CYCLE : IMPULSE : PERCENTAGE

CONCENTRATE ON ASSEMBLY
Your product moves to market...
...as fast as the slowest part.

Accelerating assembly lines with accurate parts in large quantities is our specialty.

Time saving methods and devices we have recently invented enable us to make parts better and faster for less!

The more space you devote to assembly, the more products you market. Plan on U. S. to start your assembly lines sooner.

U•S•AUTOMATIC
CORPORATION
Screw Machine Products
AMHERST • OHIO

U.S. AUTOMATIC

Get Job-Proved Performance
with Buffalo Brand
COTTON BELTINGS
for

CONVEYING
•
ELEVATING
•
POWER TRANSMISSION

• Plants looking for economy, dependability and long life in conveying, elevating and power transmission beltings will do well to investigate Buffalo Brand Solid Woven Cotton Beltings.

These tightly woven beltings are produced on specially constructed looms from pretested yarns to assure top performance on the job. They are available in a multitude of widths and thicknesses and may be had plain or treated with Asphaltum, Paraffine or the amazing new PlasTex, which has made such a hit in use conveying foods, chemicals and other materials.

Write today for descriptive folder and the name of your nearest Buffalo Brand Belting jobber.

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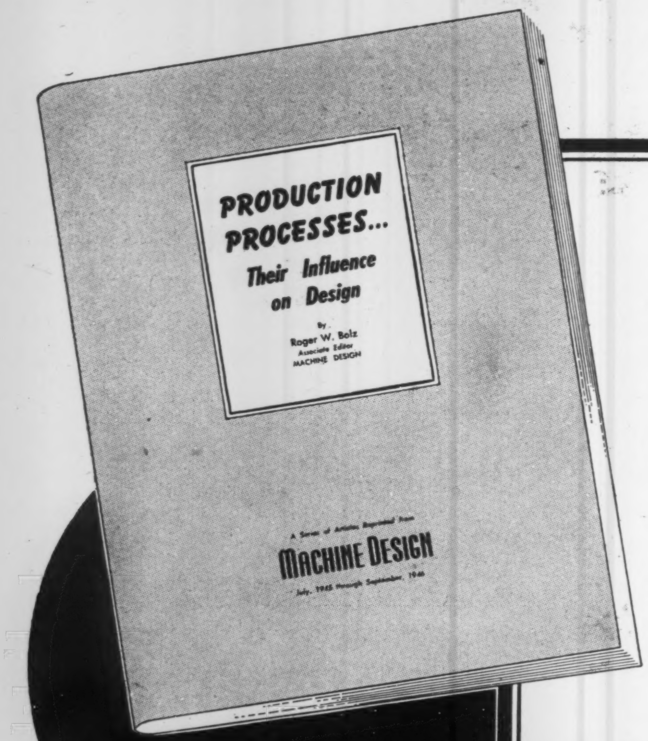
BUFFALO 7, NEW YORK
NEW YORK CHICAGO


PRODUCTION PROCESSES...
Their Influence on Design
By
Roger W. Bolz
Associate Editor
MACHINE DESIGN
A Series of Articles Reprinted from
MACHINE DESIGN
July, 1945 through September, 1946

PRODUCTION PROCESSES...

THEIR INFLUENCE ON DESIGN

By Roger W. Bolz
Associate Editor, MACHINE DESIGN

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IMPORTANCE of mass production processing methods relative to their tremendous influence upon practical, economical and satisfactory design is gaining wide recognition. Design changes to simplify and reduce the cost of manufacture after release of parts to the shop are usually costly and often cause undue delays. To assist the designer in evaluating the various processing methods available and help in achieving the advantages of maximum economy, accuracy and speed in the manufacture of tomorrow's machines, a series of articles are appearing currently in MACHINE DESIGN. The first fifteen parts, listed at the left, are now available as a bound volume.

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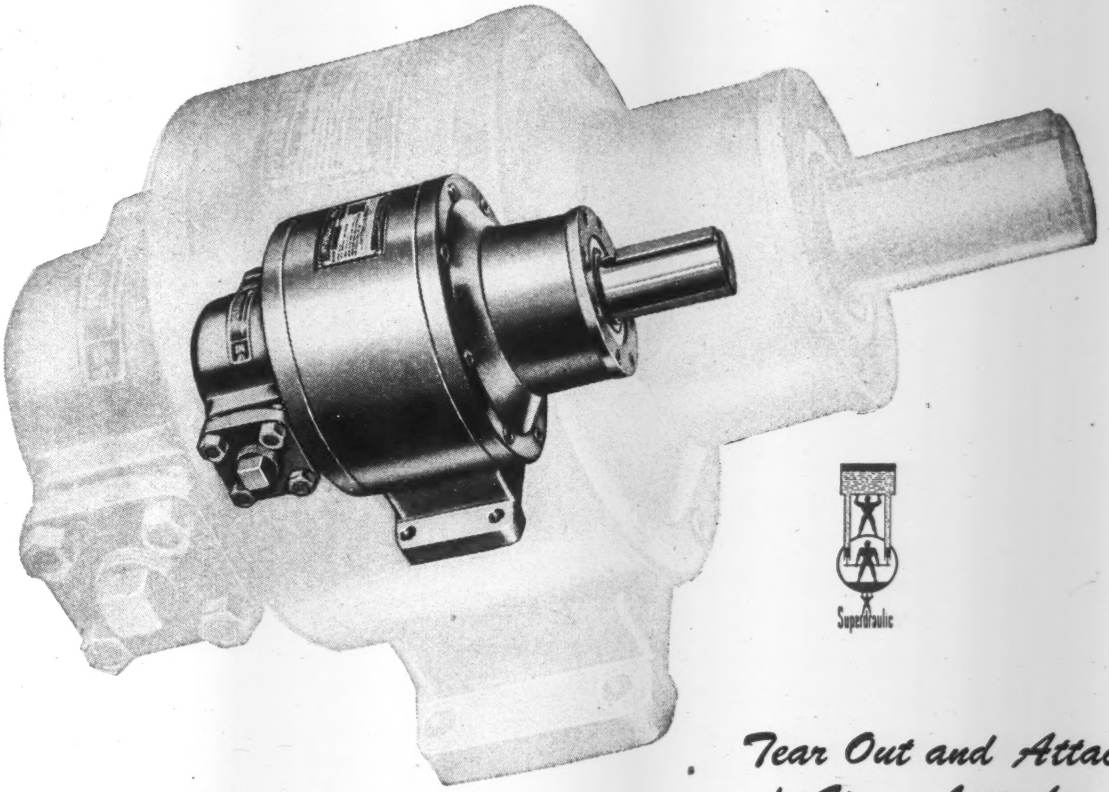

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Only 6″ in Diameter • Length 11″
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Here's the ideal pump for the many applications where high pressures must be produced from a unit of minimum size and weight.

As its name implies, Superdraulic Junior is practically a duplicate (on a reduced scale) of the famous Superdraulic 40 Horsepower Constant Delivery Pump. It delivers 5000 psi in continuous duty service, with volumes of 3 gpm at 1800 rpm, or 2 gpm at 1200 rpm. Volumetric efficiency averages 95% with the lightest hydraulic oils. Radial multi-plunger design insures smooth delivery. Perfect hydraulic balance insures thousands of hours of trouble-free service. Superdraulic Junior can also be used as a powerful reversible hydraulic motor.

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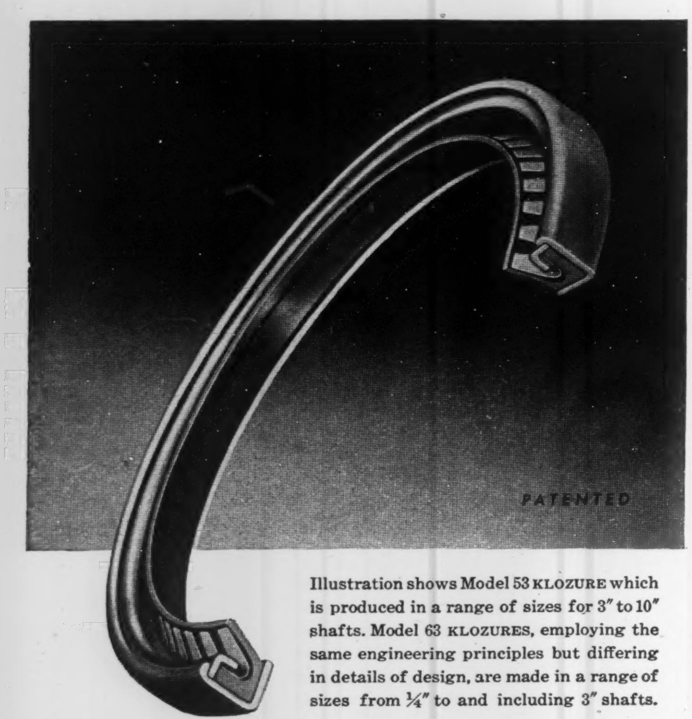

Illustration shows Model 53 KLOZURE which is produced in a range of sizes for 3" to 10" shafts. Model 63 KLOZURES, employing the same engineering principles but differing in details of design, are made in a range of sizes from ¼" to and including 3" shafts.

MODELS 53 and 63

GARLOCK KLOZURE OIL SEALS

Extreme sensitivity and flexibility of these new Models 53 and 63 KLOZURES reduce friction to a minimum and provide an efficient seal even on shafts having considerable "whip" or lateral movement. They give superior performance on high or low shaft speeds. For use under various operating conditions and on many different kinds of equipment.

GARLOCK
KLOZURE
OIL SEALS
MODELS
53 and 63

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PALMYRA, N. Y.
In Canada: The Garlock Packing Company
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60th Anniversary 1887—1947

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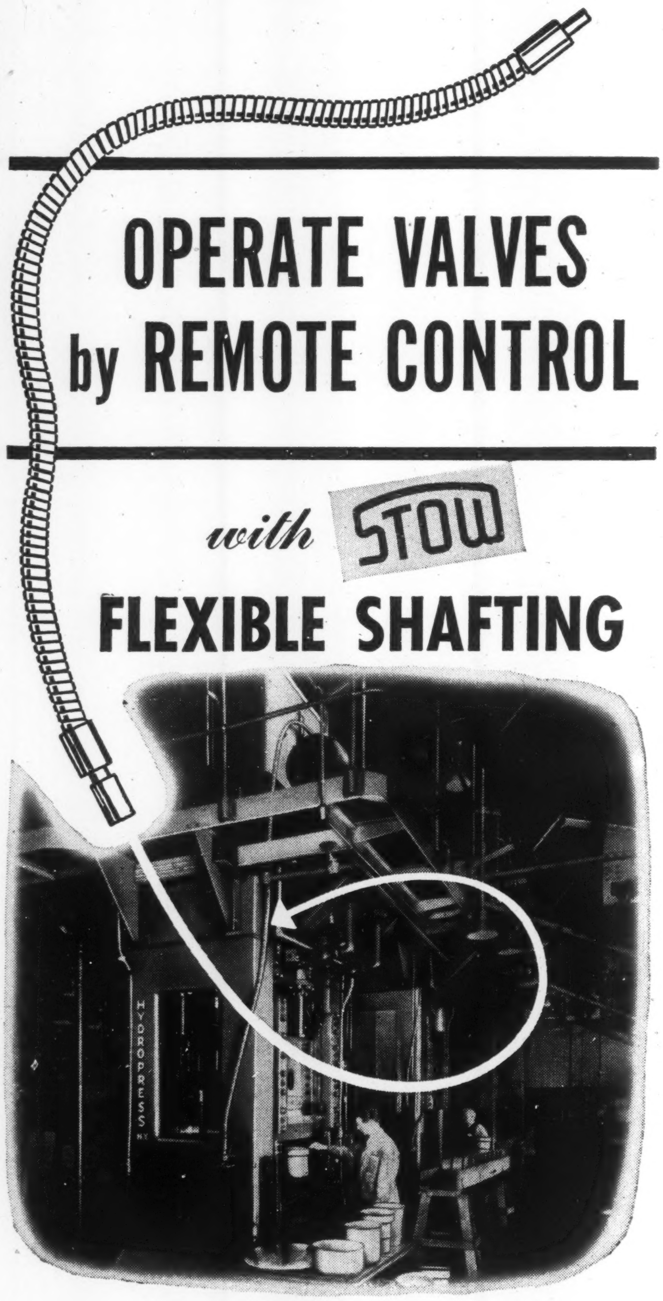
Klozure
OIL
SEAL



OPERATE VALVES by REMOTE CONTROL

with STOW FLEXIBLE SHAFTING

Oil-Hydraulic Self-contained Deep Drawing Presses Built by Hydropress, Inc., New York, N. Y.
By Courtesy of The Aluminum Company of Canada, Ltd.

How STOW Flexible Shafting is installed on large hydraulic press for valve control

Easily installed, STOW Flexible Shafting can be directed around obstacles, run at angles, and kept free-operating without binding. There is no need for reach rods, intermediate bearings, bevel gearing, or slip joints.

In some plant set-ups, STOW Flexible Shafting makes possible a central valve operating station that is quickly accessible, time-saving, simple and reliable.

Send for our informative book on remote control and power transmission via STOW Flexible Shafting.

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THE *Extra* HOLDING POWER IN CHICAGO "*SAFETY PLUS*"

In deciding what fastening to use in your products, consider the importance of the *extra* holding power in Chicago "Safety Plus" Socket Head Cap Screws. This "extra" results from the use of especially selected alloy steel, plus correct heat treating practice—combined with precision threading method designed to give full thread engagement.

The greater tensile strength of "Safety Plus" permits using fewer fastenings, resulting in a noticeable reduction in weight and a neater, sturdier construction in your products.

In addition, the smaller heads with internal wrenching permit locating "Safety Plus" screws in areas too small for protruding hexagon heads.

Make use of Chicago "Safety Plus" EXTRA strength to make your products EXTRA GOOD.

Chicago "SAFETY PLUS" line includes:

Socket Head Cap Screws • Socket Set Screws • Stripper Bolts • Square Head Dog Point Set Screws • Socket Pipe Plugs • Keys for "Safety Plus" Products.

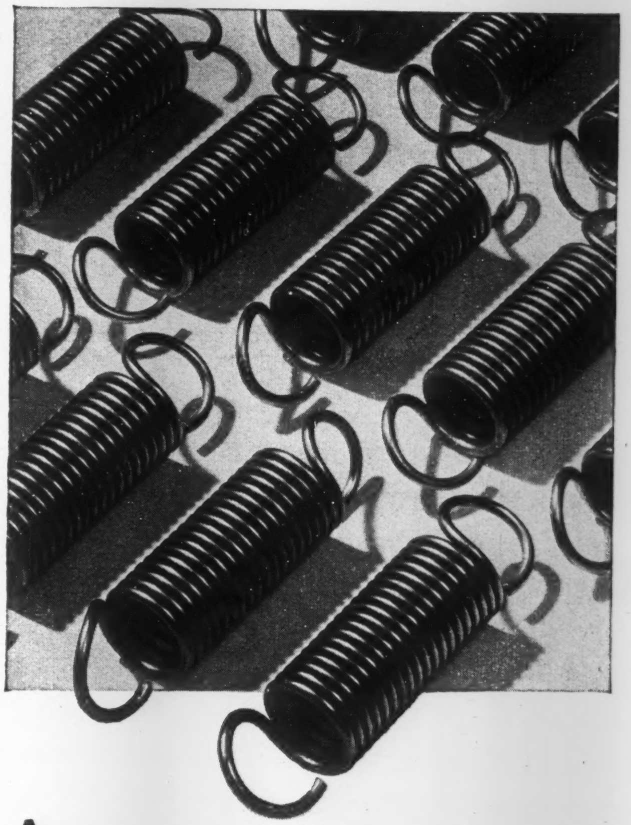
Complete line includes:

Hexagon Head Cap Screws • Square Head Cup Point Set Screws • Headless Set Screws • Fillister Head Cap Screws • Flat Head Cap Screws • Taper Pins • Milled Studs • Semi-Finished Hexagon Nuts • Semi-Finished Hexagon Castellated Nuts.

These Fine Products are sold only thru Authorized Distributors

THE CHICAGO SCREW CO.
ESTABLISHED 1872
1026 SO. HOMAN AVENUE CHICAGO 24, ILL.

SPRINGS *by* LEE



A FINE Lee Spring is metal, like any other spring. But—more important—it's men and machines. It's years and years of experience in spring science and craftsmanship, ingenious tools and instruments, hands that through long practice have developed a touch of perfection. Only this combination could turn out the *Lee-Built Springs* so far produced. Obviously, you can count on the same Lee "spring wisdom" to give you the very finest in post-war spring technique.

Our constant willingness to be of service, coupled with our reputation, is your assurance of satisfaction. The Lee Spring Company's Technical Advisory Staff will gladly help your production department in the solution of its spring problems.

Bulletins on request

LEE SPRING COMPANY, INC.
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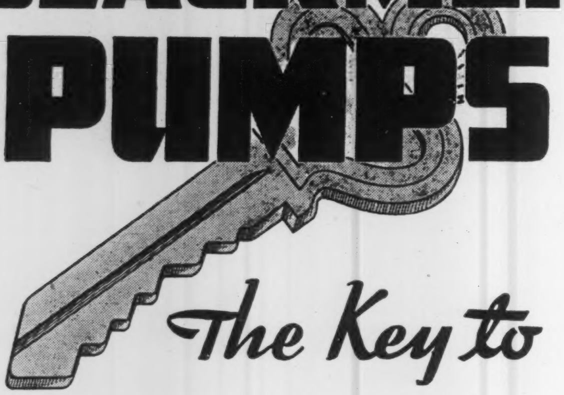
LEE-BUILT TRADE MARK SPRINGS

BLACKMER PUMPS



the Key to

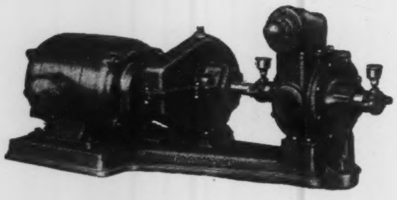
- LOWER PUMPING COSTS
- SUSTAINED PUMPING CAPACITY
- PUMP DEPENDABILITY

Write for Bulletin No. 307

FACTS about ROTARY PUMPS
BLACKMER

FACTS ABOUT ROTARY PUMPS

which explains why the "Bucket Design" (swinging vane principle) maintains pumping capacity by automatically compensating for wear and how the buckets, when finally worn out, are easily replaced and the pump restored to its normal capacity.



OUR ENGINEERS ARE AT YOUR SERVICE

BLACKMER PUMP COMPANY
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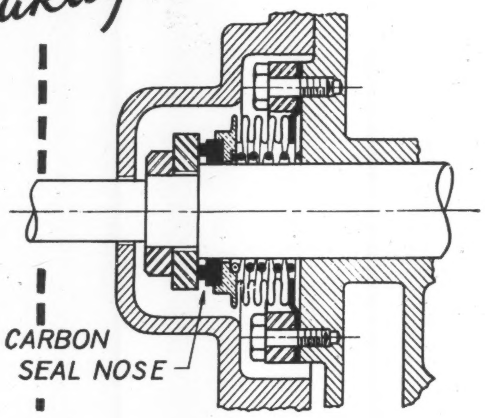
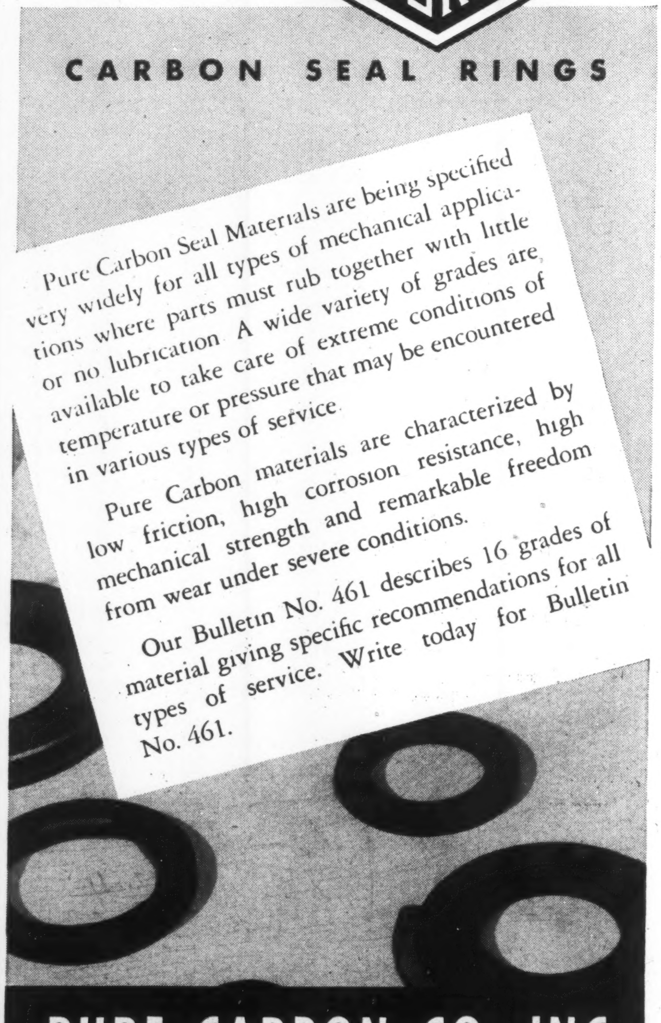
POWER PUMPS · HAND PUMPS
· EZY-KLEEN STRAINERS ·

Leakage Problem?



TRY PURE

CARBON SEAL RINGS



Pure Carbon Seal Materials are being specified very widely for all types of mechanical applications where parts must rub together with little or no lubrication. A wide variety of grades are available to take care of extreme conditions of temperature or pressure that may be encountered in various types of service.

Pure Carbon materials are characterized by low friction, high corrosion resistance, high mechanical strength and remarkable freedom from wear under severe conditions.

Our Bulletin No. 461 describes 16 grades of material giving specific recommendations for all types of service. Write today for Bulletin No. 461.

PURE CARBON CO. INC.

448 HALL AVENUE • ST. MARYS, PA.

CMP LONG COILS

for less downtime, more production

● In many grades of CMP Thinsteel you can specify extra long coils—up to 300 lbs. per inch of width. It's a good start on stepping-up production and cutting costs with your automatic equipment. With less downtime your equipment gives you more production without interruptions.

And don't forget your requirements in cold rolled strip steel in all CMP grades will be met with unvarying coil after coil accuracy. Why not check on your needs with CMP right now?

COLD FACTS ON
THINSTEEL

- **EXTRA LONG COILS** *..less downtime*
- **EXTREMELY CLOSE TOLERANCES** *...more parts per ton*
- **WIDE RANGE OF PHYSICALS AND ANALYSES** *...tailored for your products*
- **GAUGES THIN AS .001"** *...strength with lightness*
- **LOW CARBON, STAINLESS AND ALLOY GRADES**

CMP PRECISION COLD ROLLED **STRIP STEEL** THINSTEEL

GIVES MAXIMUM PRODUCTION PER TON

THE COLD METAL PRODUCTS CO.
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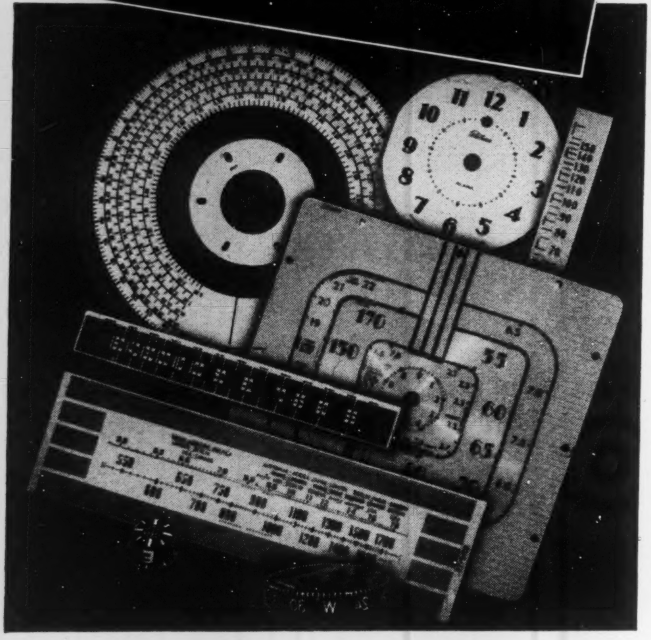
It Costs You Less to Pay a Little More for SILLCOCKS-MILLER PLASTIC DIALS



Quality, not quantity is the tradition at Sillcocks-Miller.

Of course, we cannot make all of the plastic dials industry requires, so we concentrate on producing only the best.

That's why design engineers who need plastic dials fabricated to close tolerances have come to depend on Sillcocks-Miller craftsmanship through the years.

Our understanding of the problems, our ability to produce accurately and our thorough knowledge of all types of plastics enable us to supply your needs quickly and with a minimum of effort on your part.

That's why we can say "it costs you *less* to pay a little more for Sillcocks-Miller quality."

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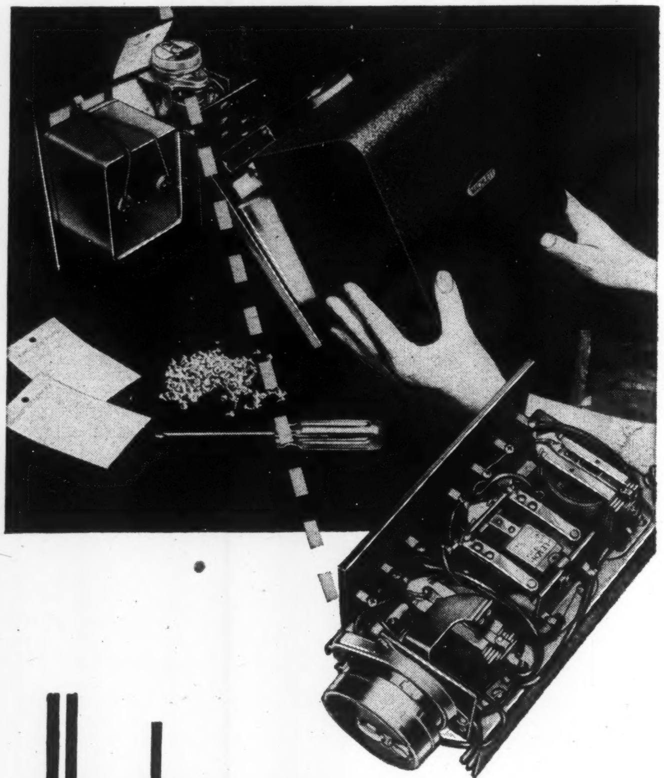
THE SILLCOCKS-MILLER CO.

10 West Parker Avenue, Maplewood, N. J.
Mailing Address: South Orange, N. J.

SPECIALISTS IN HIGH QUALITY, PRECISION-MADE PLASTICS FABRICATED FOR COMMERCIAL, TECHNICAL AND INDUSTRIAL REQUIREMENTS.



Undercover STORY . . .

The Machlett Dynamax "25" unit for diagnostic work represents the highest development of the rotating anode principle whereby the loading capacity of an X-Ray tube is greatly increased.

The motor control equipment houses a Haydon 1600 series timing motor featuring the patented magnetically operated, counter-balanced gear shift and is employed in connection with the Dynamax Motor control circuit. It provides accurate time delay between energizing motor and exposure while preventing exposure in the event connections to motor are broken or reversed.

This Haydon application story is but one of many in diversified industry . . . each playing an important part in assuring accurate and dependable timing for greater operating efficiency. If it's about time . . . consult Haydon engineers. Free catalog available

Write HAYDON, 2700 Forest St., Forestville, Conn.

HAYDON

MANUFACTURING COMPANY, INC.

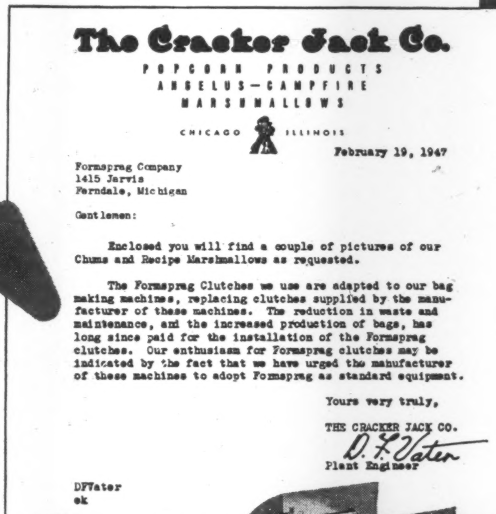
FORESTVILLE CONNECTICUT

HARNESS TIME TO YOUR PRODUCTS

SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION

CHUMS
by Cracker Jack
Recipe
CARAMEL CORN

"INCREASED PRODUCTION LONG SINCE PAID FOR FORMSPRAG CLUTCHES"



The Cracker Jack Co.

POPCORN PRODUCTS
ANGELUS—CAMPFIRE
MARSHMALLOWS

CHICAGO ILLINOIS

February 19, 1947

Formsprag Company
1415 Jarvis
Ferndale, Michigan

Gentlemen:

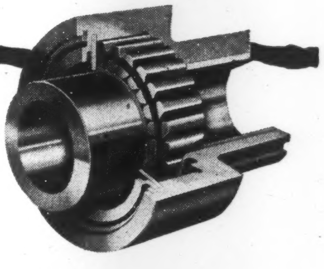
Enclosed you will find a couple of pictures of our Chums and Recipe Marshmallows as requested.

The Formsprag Clutches we use are adapted to our bag making machines, replacing clutches supplied by the manufacturer of these machines. The reduction in waste and maintenance, and the increased production of bags, has long since paid for the installation of the Formsprag clutches. Our enthusiasm for Formsprag clutches may be indicated by the fact that we have urged the manufacturer of these machines to adopt Formsprag as standard equipment.

Yours very truly,

THE CRACKER JACK CO.
D. F. Vater
Plant Engineer

DFVater
ek

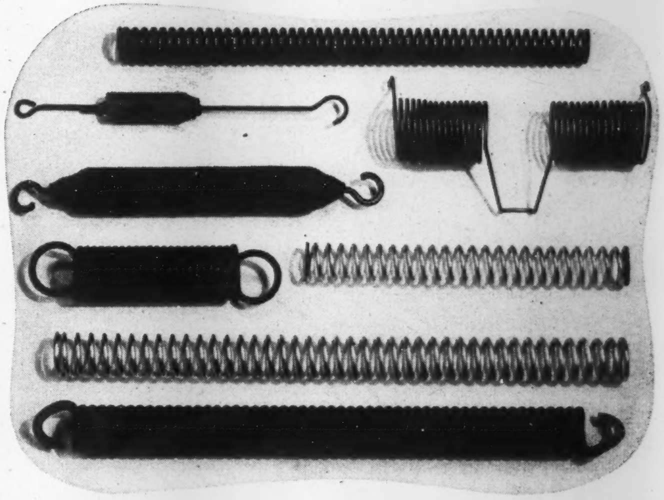


FORMSPRAG
THE FULL COMPLEMENT
Over-Running Clutch

- Formsprag Clutches are delivering outstanding money-saving performance in printing presses, machines for wrapping bread, making bags, coiling springs, making boxes, weaving textiles.

Formsprag may be able to do a job for you. If you feel you may have an application, drop us a line for full information.

FORMSPRAG Company
1415 JARVIS • FERNDALE, MICH.



"Do It Better" is the Watchword at RELIABLE!

Reliable

Excellence of craftsmanship has *always* been at a premium in our plant. That means not only exactitude and fidelity to specifications in producing springs—but endowing every Reliable spring with that extra touch of quality, which simply puts it in a class above that of ordinary commercial springs.

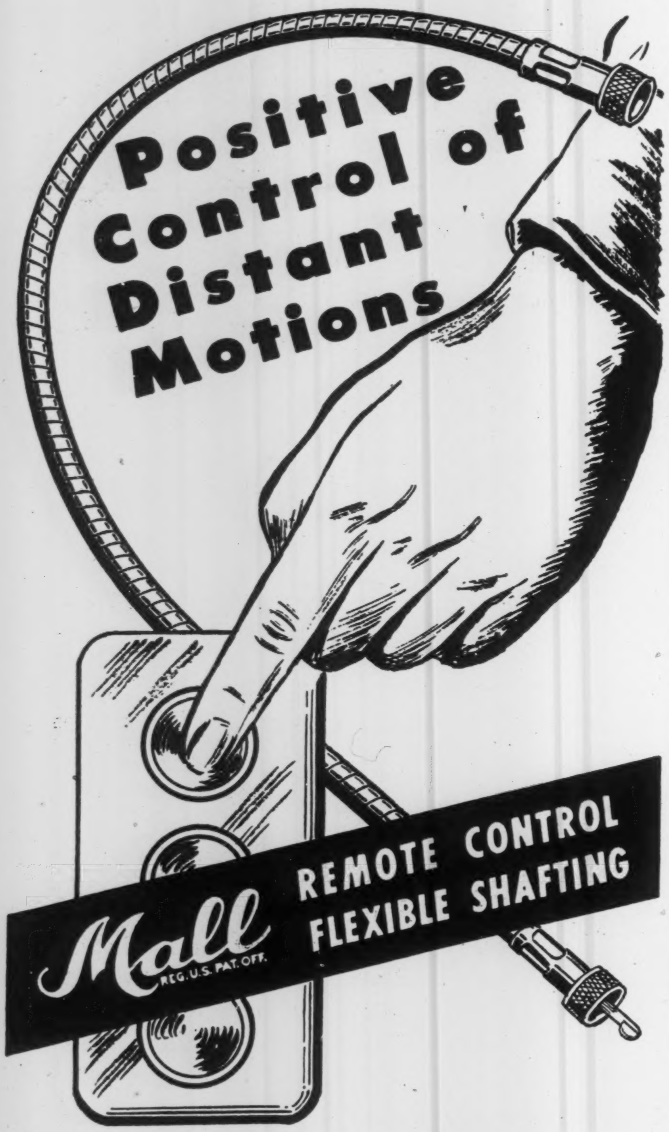
Our workers, each an expert in his line, constantly seek *perfection* in what they turn out. This policy pays off in better performance and longer life, for Reliable products. It holds old customers and keeps new ones coming. If you want that kind of cooperation from a spring organization—from the top down—order your springs, stampings, and wire forms from Reliable. It doesn't take long to see the difference.

- *When sending inquiry, describe springs as completely as possible, sending sketch, samples, or blue print. Mention any special requirements known, such as working space, initial tension, and load. Our engineers are ready to work with you. Catalog on request.*

THE RELIABLE SPRING & WIRE FORMS CO.
3167 Fulton Road **Cleveland 9, Ohio**

Representatives in Principal Cities

YOU CAN RELY ON
Reliable Springs
ROUND AND FLAT WIRE SPRINGS
CLIPS HOOKS BENDS LIGHT STAMPINGS



There is almost limitless use for Mall Remote Control Flexible Shafting in starting, stopping, indicating and regulating distant motions. Valves and skylights can be opened and closed . . . temperatures of buildings, furnaces and ovens regulated . . . machine speeds indicated on tachometers . . . vehicle speeds indicated on speedometers . . . flood lights turned to desired position . . . hands set on clocks and many other applications where positive control of clockwise and counter-clockwise motion is desired. Mall Remote Control Flexible Shafting can be furnished to your specifications—in any length or type with Metallic or Elastic Plastic covered housings and almost any combination of ends which may be splined, square, flat or threaded and made of any desired material.

★ *Over 25 years of designing, engineering and precision manufacturing experience assures correctness of design and high reliability. Write at once, giving full details of your remote control problem. Our Engineering Staff is at your disposal.*

FLEXIBLE SHAFT DIVISION
MALL TOOL COMPANY
7731 South Chicago Ave., Chicago 19, Ill.

See Our Advertisement April 5th Issue The Saturday Evening Post

Mall REG. U.S. PAT. OFF. **PORTABLE POWER TOOLS**

"SABECO" BRONZE a superior metal for bearings, seals, thrust washers and connecting rods

SABECO Bronze seals, thrust washers, bearings, connecting rods, and other parts will increase the demand for your products by increasing their efficiency and dependability. They eliminate or greatly reduce maintenance and parts replacement costs and at the same time greatly improve mechanical performance, because:

1) SABECO Bronze is made of copper, tin, and lead only, with less than 2/10 of 1% total impurities.

2) SABECO Bronze contains no rough spots to disintegrate into an abrasive compound which might damage mating surfaces.

3) SABECO Bronze parts will not score, seize, burn, corrode, or pound out.

4) SABECO Bronze parts perform satisfactorily with water as the only lubricant, and when lubrication fails they will operate with a minimum of friction until corrective steps are taken.

SABECO Bronze is available in five grades and three forms—stock bars, rough castings, and finished parts—to meet your requirements.

Write for complete particulars.

"sabeco"

SAGINAW BEARING CO., 867 S. Water St.,
SAGINAW, MICHIGAN • CABLE "SABECO"

HERE'S THE NEW LINE OF *Series K* ROPER ROTARY PUMPS

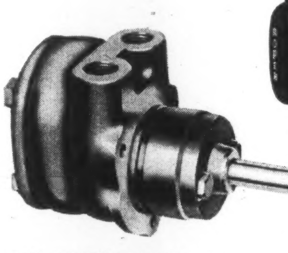


FIG. 17K PUMP HEAD with mechanical Seal. Sizes ¾, 1½, and 3 g.p.m., as illustrated. Fig. 18K is equipped with built-in relief valve. Packed Box is available.

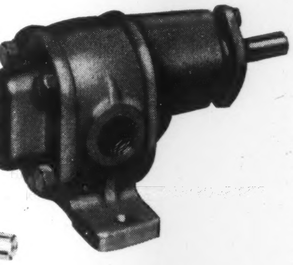


FIG. 1K with Packed Box. Available in 5 g.p.m. size only. Fig. 2K is equipped with built-in relief valve. Mechanical Seal is available.

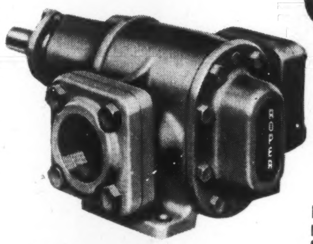


FIG. 1K with Packed Box — supplied in 30, 40, 50 g.p.m. sizes with companion flanges. FIG. 2K equipped with built-in relief valve. Mechanical Seal available on all models.

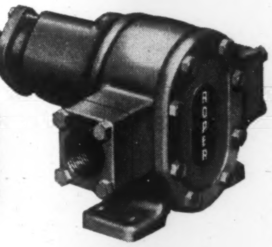


FIG. 1K with Packed Box — supplied in 10, 15, 20 g.p.m. sizes with companion flanges. FIG. 2K equipped with built-in relief valve. Mechanical Seal available on all models.

¾ TO 50 G. P. M. — PRESSURES TO 150 P. S. I.

Adaptable to a wide range of jobs . . . pressure lubrication, hydraulic service, fuel supply, or transfer work pumping clean liquids. These Ropers are self-priming, operate in either direction, handle total suction lifts up to 25 feet. Direct connected, belt, or chain driven. Because of the new Roper venturi suction and discharge principle, energy loss from cavitation, turbulence, and friction is minimized. This proportional means of distributing viscous liquids uniformly across the gear face increases operating efficiency . . . adds quietness and reduces power costs . . . permits gears to handle a wide range of viscous liquids at standard motor speeds.

Get All of the Facts — Send For Booklet

Complete Model "K" details including specifications, exploded view of construction features, wide range of mountings, etc. Also describes other models up to 300 G.P.M., pressures up to 1000 P.S.I.

ROPER *Rotary Pumps*

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● We have them every day, *but* we ask for them . . . precision parts have been our business for 44 years.

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That's why *the Clinton is in demand* by users, dealers and manufacturers employing compact air-cooled power—Built by master craftsmen employing the most modern tools and equipment, the Clinton has set a new standard for performance—The Clinton enjoys an enviable reputation for economy of operation, longer service and staying power—SHOWN IS THE GEAR REDUCTION MODEL BUILT FOR EQUIPMENT REQUIRING SLOW DRIVING SPEEDS—THREE RATIOS AVAILABLE: 6 to 1—4 to 1—2 to 1 AS REQUIRED.

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FEEDALL is a fully automatic hopper feed, entirely self-driven unit, with variable speed drive and automatic relief mechanism built-in to eliminate serious injury due to overloading the pick-up blade. Entire unit can be attached to chute or magazine feed of a machine and continuous automatic operation will result.

Adjustments at chute and hopper permit setup for plain cylindrical work to 1¼ by 6 in. and for headed or shouldered pieces to 1⅛ by 6 in.

Send samples or drawing and name your feed problem for our recommendations.

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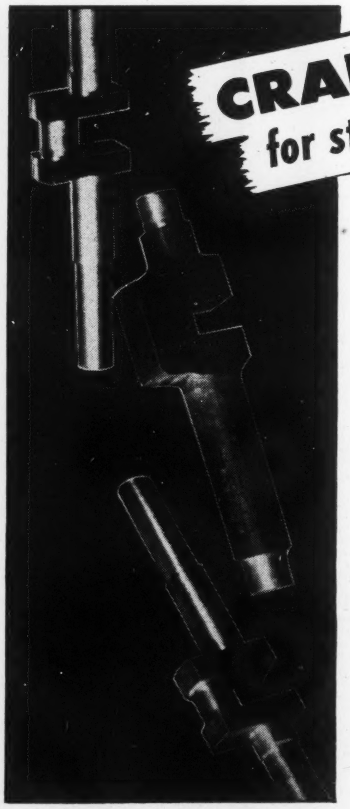
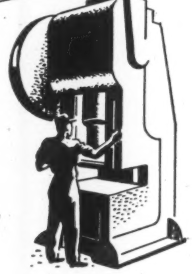


CRANKS for stalled machinery



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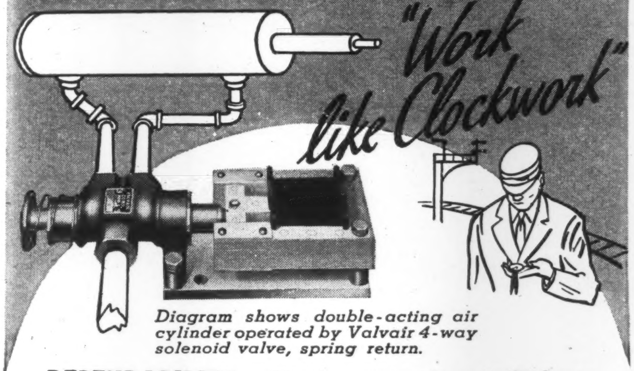

Diagram shows double-acting air cylinder operated by Valvair 4-way solenoid valve, spring return.

DEPENDABILITY — That's outstanding in Valvair performance. Solenoids are Stellite-welded to resist wear; do not mushroom. Standard Valvairs have operated over 2,000,000 times at 100 lbs. with never a leak. *Exclusive features.* Patented basic design eliminates metal seats; non-corrosive (cast bronze body, stainless steel parts); full pipe area used with minimum drop. 2-way, 3-way, 4-way types. Get full details and prices.

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Help **FOR YOUR STUFFING BOX PROBLEMS . . .**

JC

Getting steam or liquids into rotating machine parts used to mean a lot of trouble with stuffing boxes and steam fits. The Johnson Joint has changed all that. It's completely packless, self-oiling, self-adjusting and even self-aligning. Industry is finding new uses for it every day. Type B illustrated provides for condensate removal; other styles and sizes for all needs. Write for details.

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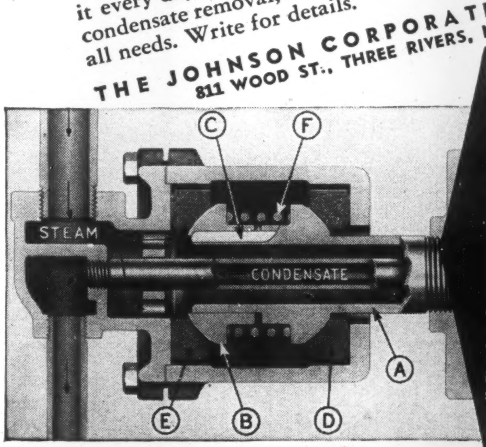
811 WOOD ST., THREE RIVERS, MICH.

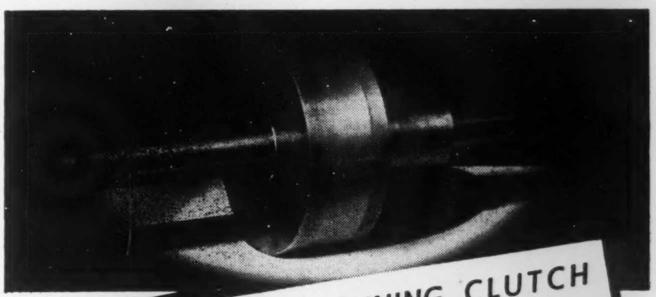


Nipple (A) connected to roll. Collar (B) is keyed (C) to nipple, but fits loosely so pressure can fill housing and force seal ring (D) in place. Both rings (D and E) are of carbon graphite, eliminate oiling and packing. Spring (F) is for initial seating only.

JOHNSON *Rotary Pressure* **JOINTS**

Clutches by **HILLIARD**

HILLIARD CLUTCHES AND COUPLINGS ARE EXCELLENT FOR ALL CLASSES OF MACHINERY



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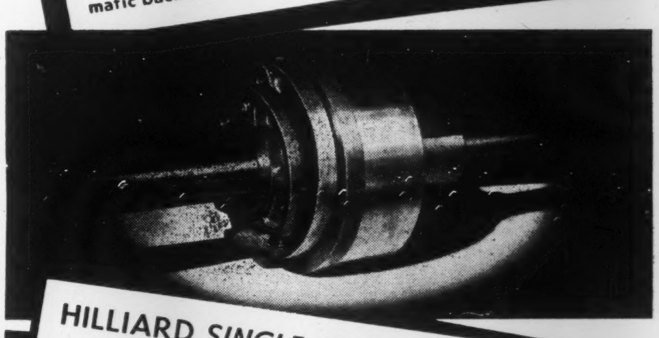
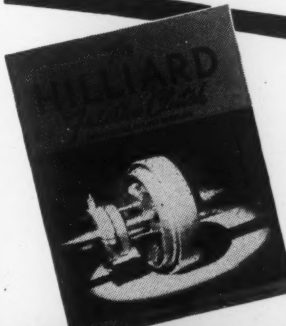
A "Free Wheeling" Clutch of simple design recognized for many years as "Standard Equipment" for Automatic Dual Drive operation – Automatic operation of 2 Speed drive – As a ratchet permitting infinite adjustment and as an automatic backstop. Furnished in a number of types.



HILLIARD SINGLE REVOLUTION CLUTCH

Wherever extremely accurate control of intermittent machine operation is essential the Hilliard Single Revolution Clutch is unequalled. Its accuracy has won for it the acceptance of Industry for cutting, punching and packaging operations.



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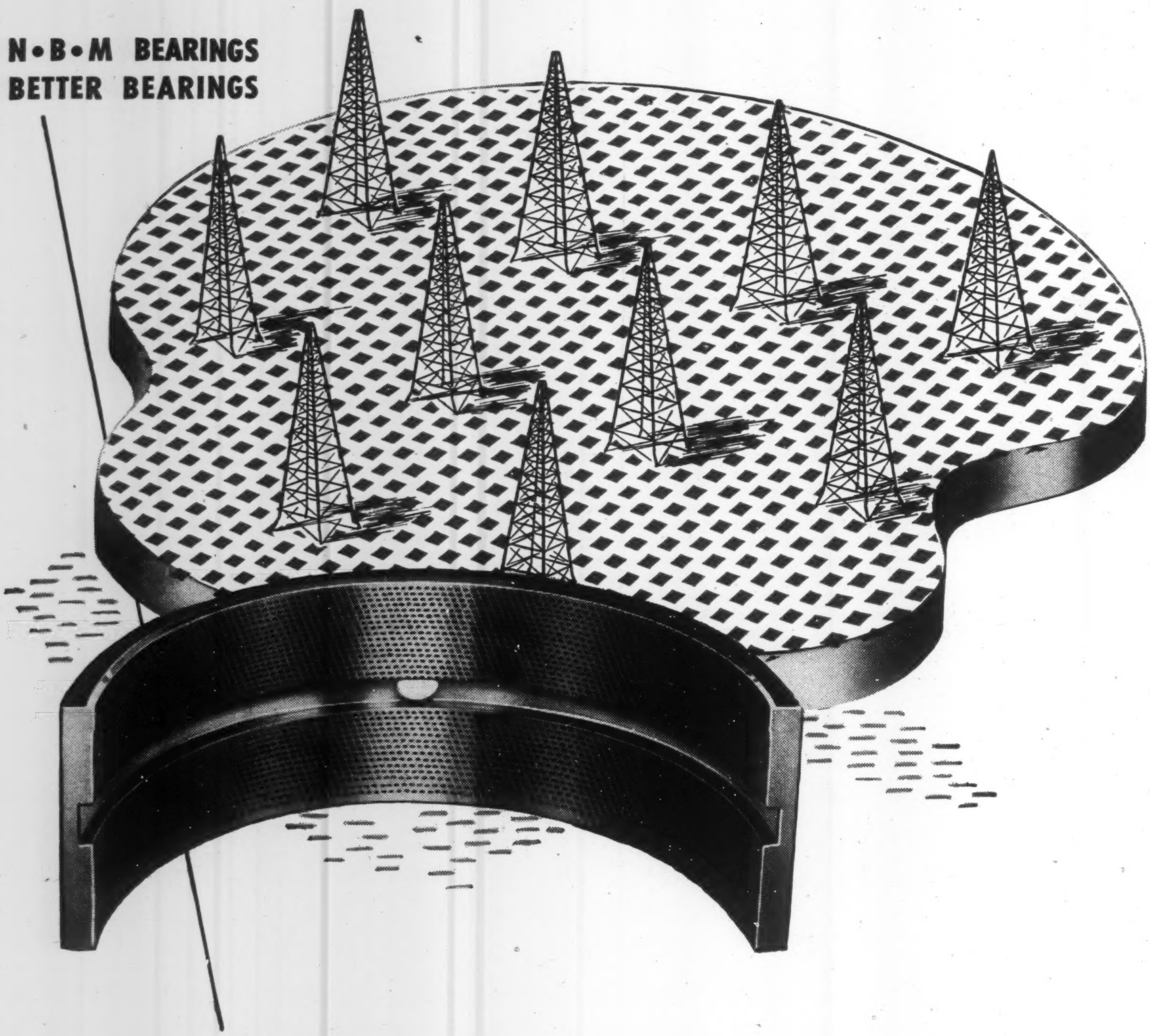
BETTER BEARINGS



N•B•M GRIDDED BEARINGS PROTECTED BY THOUSANDS OF SAFETY "OIL WELLS"

Each precision-spaced grid becomes a lifesaving "oil well" which increases the overstress safety factor of new N-B-M Gridded Bearings. They protect shaft and bearing during periods of initial lubrication, rapid acceleration, and extreme stress.

Centrifugally Cast N-B-M Gridded Bearings are true lifesavers for heavy-duty, high-speed machinery. We invite your inquiries for special applications. Write today for complete engineering data.

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HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

1. Power Driven Brushes

Fuller Brush Co.—36-page illustrated booklet describes Fullergript power driven brushes for use in wide range of machines. Types for use in equipment for tanneries, steel strip mills, dairies, food packing plants, cotton and woolen mills, bakery, confectionery and other plants are described. Information of particular value to design engineers is included.

2. Automatic Controls

General Controls Co.—52-page illustrated catalog No. 52C contains engineering data as well as operating pressures and list prices of all automatic control equipment made by company. Line includes automatic controls for pressure, temperature and flow of gas, oil, water, steam, refrigerants and other fluids.

3. Thermostats

Fenwal Inc.—74-page illustrated loose-leaf type technical book entitled "Thermoswitches" describes complete line of Thermoswitch thermostats for applications in all types of heat control and temperature detection installations. Engineering data, case studies and price information are included.

4. Filters

Greer Hydraulics, Inc.—4-page illustrated pamphlet covers engineering data, performance charts and reports of actual tests of Micronic oil filters. Details of construction and materials used are covered by exploded view of unit.

5. Screw Thread Data

Greenfield Tap & Die Corp.—56-page illustrated technical handbook is entitled "Guide to Screw Thread Fits." Information contained is compendium of important engineering data relative to screw threads and is presented in quickly usable form.

6. Flexible Shafting

Walker-Turner Co.—20-page illustrated book presents engineering data and application information about flexible shafting, flexible housing and flexible shaft assemblies for aircraft instruments, appliances, industrial machinery and special applications.

7. Die Casting Machines

Miller-Taylor Tool Co.—6-page illustrated catalog "Cast-Master" presents general specifications, production figures and operation data on Cast-Master die casting machines. Three models are described. Attachments and accessories for processing zinc, tin, lead, aluminum, magnesium and brass are illustrated.

8. Capacitor-Start Motors

Emerson Electric Mfg. Co.—4-page illustrated bulletin No. X5526 presents complete line of ⅙ to ¾-horsepower capacitor-start electric motors. Details of construction, dimensions, diagrams and ratings in accordance with new NEMA fractional horsepower motor standards are covered.

9. Socket Screws

Safety Socket Screw Co.—4-page illustrated folder "Blue Devil Socket Screw Products" describes line of socket head screws and socket head cap screws. Specifications as to length and diameter are charted. Prices are included.

10. Flexible Couplings

John Waldron Corp.—20-page illustrated catalog No. 57 describes series "A" flexible couplings. Complete engineering data and specifications are given for standard and special types. Feature of series is increased bore capacity which permits use of smaller sized couplings.

11. Limit Switch

Friez Instrument Div., Bendix Aviation Corp. —2-page illustrated bulletin describes model 510,000-1 Amptrol precision switch. Applications, operation, construction and specifications are given. Low actuating pressure, short travel differential and high load capacity are features.

12. Casting Materials

Kerr Dental Mfg. Co., Industrial Div.—20-page illustrated catalog "Industrial Precision Casting Equipment and Materials" contains pertinent information relative to precision casting operations utilizing Kerr equipment. Basic steps in casting process are illustrated.

13. Air-Hydraulic Cylinders

Logansport Machine Co.—16-page illustrated catalog No. 471 covers engineering data, applications and operation of Air-Draulic cylinders which are air powered, oil regulated power units. They are designed for pushing, pulling, pressing, clamping, holding, lifting and for other power movements in any direction.

14. Mercury Clutches

Mercury Clutch Corp.—Illustrated data sheet No. 105-11-44 describes 450 series type C clutches designed to meet requirements for automatic clutches from 1 to 7½ horsepower. They are suitable for use with electric motors or internal combustion engines.

15. Helical & Bevel Gears

Beaver Gear Works, Inc.—4-page illustrated folder "Is This the Kind of Gear You Need?" provides information on line of medium and small size spur, helical and straight bevel gears made to customer's specifications.

16. Pressed Shapes

Lukens Steel Co.—8-page illustrated bulletin form No. 271 describes and illustrates typical pressed shapes and outlines advantages of specifying Lukens pressed shapes in design of various types of machinery and industrial equipment.

17. Woven Materials

General Electric Co.—4-page illustrated catalog No. 6900 describes new Multi-Weaving process for weaving metal, plastic, fabric or wood. Catalog will aid product designers and manufacturers in choosing custom made material for particular need. Suggested applications include use of woven material in aircraft, automobiles, household appliances, novelties, building construction, ship building and in field of electronics.

18. Automatic Hopper Feeds

Feedall Machine & Engineering Co.—Illustrated data sheet "For Increased Production at lower cost. . . " presents information on model No. H-1000 self-driven automatic hopper feeder. Drive is variable speed and automatic relief mechanism is incorporated. Oscillating blade picks up work and deposits it in slot of chute.

19. Liquid Filters

Marvel Engineering Co.—4-page illustrated bulletin form No. 102 presents complete engineering information on sump type Synclinal liquid filter. Advantages of use include increased capacity, no wearing parts, easy disassembly, increased operating time because of maximum filtering area, replaceable parts and full protection to filtering element.

20. Drum Controllers

Euclid Electric & Mfg. Co.—3-page illustrated folder No. 1012 presents information on drum type controllers which are used with direct current series motors on cranes and hoists to provide series hoisting and lowering.

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21. Electroplating Controls

Taylor Instrument Cos.—16-page illustrated bulletin No. 98166 features temperature controls for electroplating. Process temperature control recommendations, recording or indicating Fulscope controllers, heating and cooling with bath circulation and element controls are described.

22. Manufacturing Facilities

Weatherhead Co.—30-page illustrated booklet "Prospecting for Perfection" presents description of scientific research and engineering facilities available for the design, testing and development of products. Present line of fittings and flexible hose assemblies is illustrated.

23. Lubricant Pumps

Trabon Engineering Corp.—12-page illustrated bulletin No. 469 presents information on line of automatic, motor driven, manually operated and mechanically driven type lubricant pumps for handling oil or grease.

24. Synthetic Resin

Nukem Products Corp.—12-page illustrated catalog "Nukemite Acid and Alkali Proof Resin Coating" presents information on chemical and physical properties of synthetic resin coating which is tough, impenetrable and elastic film. Dielectric strength, temperature resistance and adhering qualities are discussed.

25. Oil Filters

Briggs Filtration Co.—10-page illustrated filable loose-leaf type booklet entitled "Briggs Oil Filters" describes standard line of oil filters for continuous maintenance for all fuels, lubricants, hydraulic oils and coolants. Specifications and application data are included.

26. Flexible Couplings

American Flexible Coupling Co.—4-page illustrated folder No. 462 presents technical data and service information on four series of American flexible couplings and four series Amerigear couplings. Units feature three-part construction.

27. Hydraulic Pumps

Denison Engineering Co.—8-page illustrated catalog "Denison High Pressure, High Volume HydrOILic Pumps" deals with series 3500 hydraulic pumps. Typical performance chart and information on applications and mounting are included.

28. Bronze Bushings & Bearings

Johnson Bronze Co.—80-page illustrated catalog No. 460 presents information on line of general purpose bearings, universal cored bars, hexagon bars, babbitt, graphite bearings, electric motor bearings and self-oiling bearings. Hundreds of sizes are listed and applications suggested.

29. Fuses

Littlefuse, Inc.—24-page illustrated catalog No. 9 reveals pertinent information on full line of electrical protection fuses. Included is technical information relative to fuse mountings, extractor posts, neon indicators and line fuse retainers.

30. Variable Speed Pulley

DoAll Co.—4-page illustrated folder No. B46-901 describes Speedmaster variable speed pulley. Models S0-4B and S1-4B are adjustable to provide exact required speed for varying conditions of operation on machines requiring fractional horsepower drives.

31. Gears, Cams & Machine Parts

Indiana Gear Works—16-page illustrated catalog "Precision Doesn't Cost—It Pays" presents complete inventory of production equipment available for the manufacture of gears, cams and precision machine parts.

32. Powdered Metal Parts

Keystone Carbon Co.—44-page illustrated catalog "Powder Metallurgy" is devoted to powder metal parts and powder metal bearings. Catalog covers line of self-lubricating porous bronze plain bearings, flanged bearings and self-aligning spherical type bearings. Section deals with correct design of powdered metal parts.

33. Centrifugal Castings

Sandusky Foundry & Machine Co.—4-page illustrated folder No. 541 reveals design and quality features of nonferrous centrifugal castings for use as paper mill roll shell, pump rotors, tube bushings and cross bars. Castings are available in diameters from 3 to 46 inches and in lengths up to 347 inches depending upon dimensions involved.

34. Solenoids & Rectifiers

George H. Leland, Inc.—34-page bulletin describes Ledex rotary solenoids and rectifiers. Two basic designs of solenoids in 1⅞ and 2¼-inch diameters are discussed and rectifiers capable of converting alternating to direct current for operating solenoids from alternating current source are covered.

35. Regulating Valves

A. W. Cash Valve Mfg. Corp.—4-page illustrated bulletin No. 199 deals with Cash-Acme small volume pressure reducing and regulating valves developed for special installations. Standard and special designs available are described.

36. Flexible Couplings

Falk Corp.—32-page illustrated bulletin No. 4100 describes line of Steelflex couplings available in any size for any type of service. In addition, complete simplified selection tables are provided for both motor and turbine applications.

37. Hydraulic Cylinders

National Hydraulic Co.—16-page illustrated bulletin No. 101-H covers line of honed and highly polished hydraulic cylinders which produce minimum amount of friction in operation. Step type piston rings are used. Working pressure tables are included.

38. Pneumatic Clamping Unit

Airop, Inc.—6-page illustrated folder "Air Operated Devices" presents specifications of air operated clamping devices for application on milling, riveting and welding machines and on drilling machines. Units operate on line pressures of from 40 to 150 pounds and can be used in multiple series actuated by one control.

39. Vitreous Enamel Resistors

P. R. Mallory & Co.—8-page illustrated folder No. VER-1146 contains detailed descriptive information regarding vitreous enamel fixed and adjustable power resistors which are designed for industrial electrical and electronic applications. Resistance values, ratings, dimensions and other essential information are given.

40. Fin Tubing

C & O Mfg. Co.—4-page illustrated folder "Individual Fin Tubing" discloses physical data on typical standard sizes of round and square fin tube elements for wide range of heat exchange applications. Tubing is expanded and bonded to fin collar for thermal contact. It is available in straight lengths, U-bends, coils and in special shapes.

41. Motor Controls

Arrow-Hart & Hegeman Electric Co.—138-page illustrated catalog No. 10 is thumb-indexed for ready reference to complete line of motor controls including manual and magnetic starters, accessories and enclosed switches. Complete price list, dimensions and specification data are included.

42. Wire Insulation Saturants

Bakelite Corp.—16-page technical data booklet describes Zyrox brand saturants for wire and cable insulation. Chemical, physical and electrical properties are covered. These saturants applied to fibrous materials used for insulating purposes retard moisture penetration and flame. Applications of treated wire and cable are outlined.

43. Laminated Material

Haskelite Mfg. Corp.—12-page illustrated bulletin "Plan With Plymetl" presents line of laminated structural Plymetl which is available to meet wide range of specifications as to strength and weight. Stock size panels of material are limited only by stock sheet size of metal used for faces. Thickness range is from ⅛ to 1¼ inch. Bending, molding, sawing, drilling, boring and routing operations are discussed.

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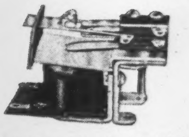
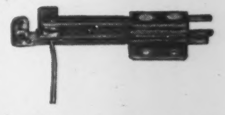
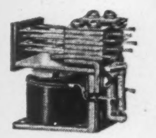
This trio of *standard* Guardian Stepping Relays: (1) continuous rotation, (2) electrical reset, (3) add and subtract—will start you off with a minimum of design and keep your product operating indefinitely. The Guardian Steppers shown are adaptable to numerous applications: automatic circuit selection; automatic sequence selection of circuits; automatic sequence cross-connection of circuits. They are used in automatic business machines, production totalizers, conveyor controls, animated displays, telephony, remote tuning, with a host of additional uses you will soon discover. On each, the contact finger rotates counter-clockwise. All three Steppers follow 10 pulses per second within the rated voltage range of the relay. Special construction prohibits skipping or improper indexing of the ratchet. Available in separate units or in combination with relays, contact switches, solenoids; completely assembled and wired to terminals; mounted on special bases or in enclosures. "Special" modifications are obtainable in production quantities. Write for Bulletin SR.



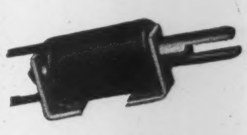
Series 100 Snap-Action Relay



Guardian Featherub Switch



Series 500 Midget Relay



Series 1-A Solenoid

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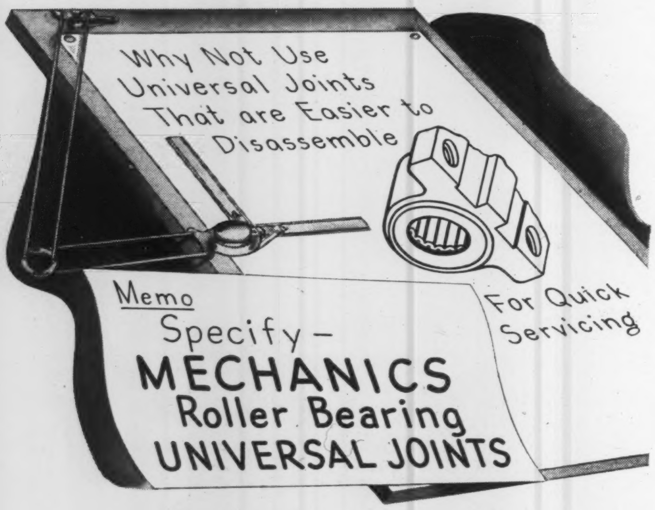

The flange type bearing assemblies in MECHANICS Roller Bearing UNIVERSAL JOINTS can be lifted out, simply by removing eight screw bolts that hold them in place.

A wrench and screwdriver are all the tools needed to remove and replace worn flange-type bearing assemblies. The operation requires only fifteen minutes.

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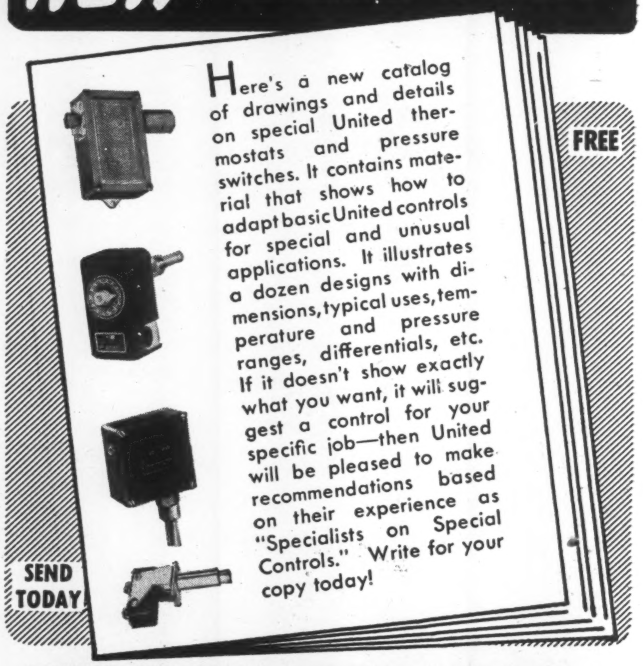

Here's a new catalog of drawings and details on special United thermostats and pressure switches. It contains material that shows how to adapt basic United controls for special and unusual applications. It illustrates a dozen designs with dimensions, typical uses, temperature and pressure ranges, differentials, etc. If it doesn't show exactly what you want, it will suggest a control for your specific job—then United will be pleased to make recommendations based on their experience as "Specialists on Special Controls." Write for your copy today!

THERMOSTATS & PRESSURE SWITCHES

United Electric Controls Company
DEPT. B, 69-71 A STREET, BOSTON 27, MASS.

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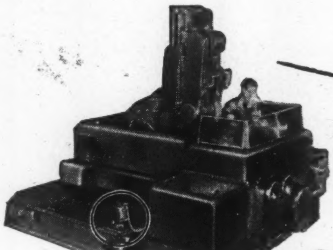
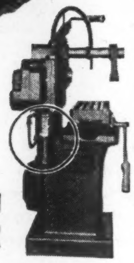


Pratt & Whitney 26" Gear Grinder in operation. Equipped with ½ H.P. Model HL-2 Gusher Coolant Pump.



Kent - Owens #2-20 Hydraulic Milling Machine, equipped with 1/10 H.P. Model 2 - P3 - Short Gusher Coolant Pump.

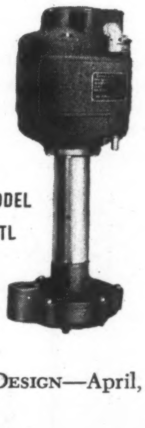
There's a . .

RUTHMAN GUSHER
COOLANT PUMP
for every metal cutting operation

There is a size and model Gusher Coolant Pump to fit your exact needs, from 1/10 to 2 H.P. up to 209 gallons-per-minute capacity.

Your coolant system worries are over when a Ruthman Gusher Coolant Pump is installed on your machine.

Write for Catalog 10-C

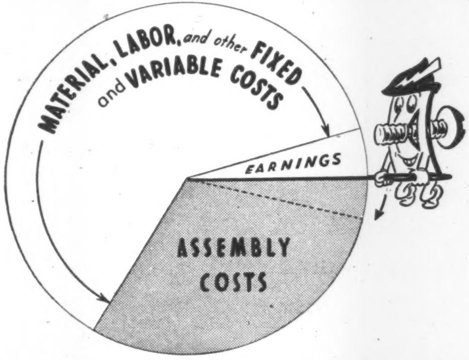


MODEL TL

THE RUTHMAN MACHINERY CO.

1811 Reading Road, Cincinnati, O.

LET *Speed Nuts** PUSH DOWN Your Assembly Costs... *To Restore Normal Earnings*


MATERIAL, LABOR, and other FIXED and VARIABLE COSTS
EARNINGS
ASSEMBLY COSTS

In building any product, the most *flexible* cost factor is *assembly* While reductions in other costs are difficult at best, ASSEMBLY COST can be pushed down drastically

And you can do it NOW, to restore normal earnings and meet the coming competition.

The SPEED NUT SYSTEM of Spring Tension Fastenings is doing cost-saving jobs that may surprise you when you see the details.

If you want to truly modernize your entire assembly methods, to assure fair profits, investigate what the SPEED NUT brand of fasteners can actually do for you NOW First step is to send assembly details for a complete no-charge fastening analysis

TINNERMAN PRODUCTS, INC. **2085 FULTON ROAD, CLEVELAND, OHIO**

*Speed Nuts**

MORE THAN 4000 PATENTED SHAPES AND SIZES

*Trade Mark Reg. U. S. Pat. Off.

FASTEST THING IN FASTENINGS

SIMPLE and EFFICIENT
DIRECT DRIVE COUPLINGS

This exclusive direct drive coupling, with rubberized cushion gripped permanently by die-cast ends, has no parts to get out of order, or to lubricate. Minimizes misalignment, free end float, and backlash. Custom-made for specific job. Lengths from 2½" up. Bores $\frac{5}{16}$", ⅜", $\frac{7}{16}$" and ½". A million giving satisfactory service.

Write for sample and further details.

GUARDIAN PRODUCTS CORP.
212 E. MICHIGAN STREET
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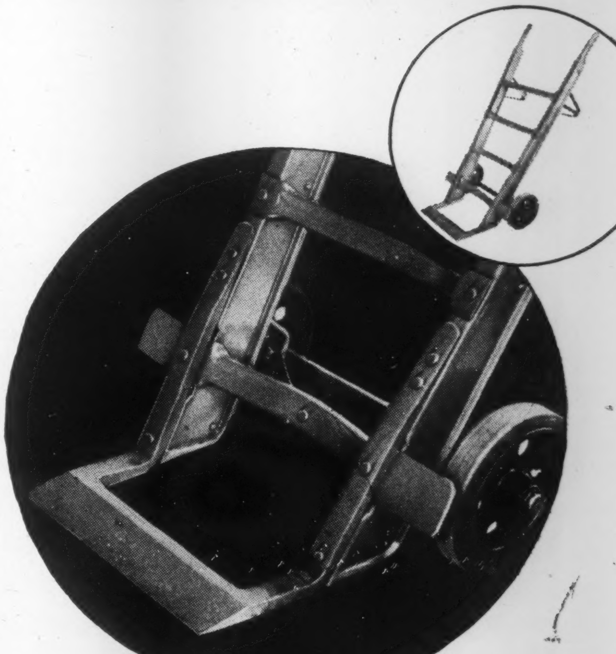
A TOUGH TEST FOR NATIONAL DROP FORGINGS

—and they can take it



The front and side nose pieces of hand trucks take a continuous beating,—and on such sturdy trucks as those made by the American Pulley Company National forgings are chosen.

On more and more different products forgings are being used because they provide maximum strength, unparalleled toughness and tremendous fatigue resistance. The fibre-like grain structure of National forgings are reinforced at areas of greatest impact and wear.

Write us today for booklets describing our standard line of SAE yoke and rod ends, container handles and knife blades, etc.:—and send us your inquiries for custom drop forgings.

The Trademark "N" is your guarantee of Fine Quality Forgings.

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DROP FORGING DIVISION
NEWARK 5 NEW JERSEY

If it's a Forging— See Billings

Our Forging Engineers are constantly aiding in the design or redesign of forged parts for every conceivable type of product—some tough, some easy—each a production job, fast and in quantity.

May we help you?

No. 9

WRITE OUR FORGING DIV.

Billings Forging Designers and Production Engineers are available for consultation . . .

THE BILLINGS & SPENCER CO.
MAIN OFFICE AND PLANT
HARTFORD 1, CONN. U. S. A.

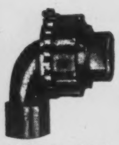
B
WRENCH MAKERS SINCE 1869

5 Features Make FLEXO JOINTS Outstanding

- Unrestricted flow in all positions.
- Flexibility of hose with the strength of pipe.
- Low Maintenance Cost.
- No Small or complicated parts.
- No Ground Surfaces to Wear.

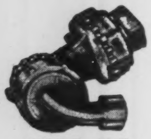
STYLE "A"

In any moving feed line used to convey steam, compressed air, gas, water, oil or other liquids—specify Flexo Joints for dependability and constant service. Simply and ruggedly constructed with full protection from dirt and grit. Flexo Joints work smoothly with no binding or restriction of flow in any position . . . The flexibility of hose with the strength of pipe.



STYLE "B"

STYLE "F"



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Made in 4 styles of 4 simple parts. Pipe sizes from 1/4" to 3".

Write for illustrated literature and data.

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DIESEL STARTING POWER

Supplied by **WISCONSIN** *Air-Cooled* **ENGINES**

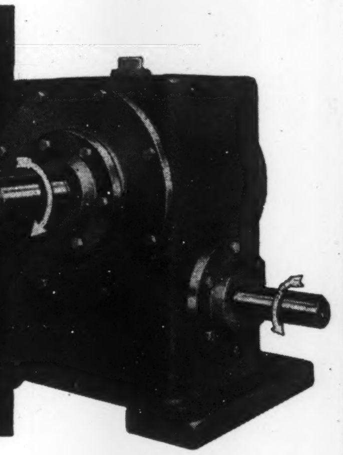
On this Chicago Pneumatic Diesel installation at the Armstrong Paint and Varnish Works, Chicago, Illinois, dependable emergency standby starting power is supplied by a single cylinder Wisconsin Heavy-Duty Air-Cooled Engine.

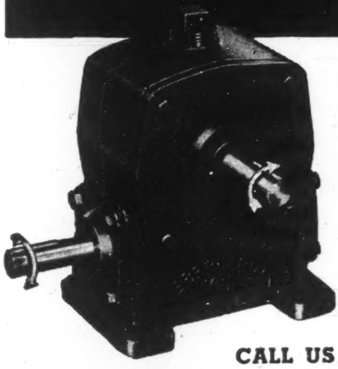
Wherever there is a power job to be done, within a 2 to 30 hp. range, you can depend on Wisconsin Engines for a quick start under any climatic condition and complete freedom from cooling chores and troubles.

Wisconsin Engines are available in a complete range of sizes to fit a great diversity of power applications. Write for detailed information.

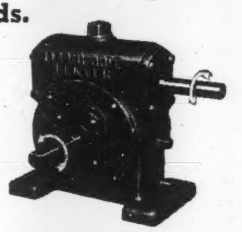
Most H.P. per pound
WISCONSIN MOTOR
Corporation
MILWAUKEE 14, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines

Speed Reducers FROM STOCK





Manufactured in a practical range of sizes and reductions. We also build reducers to meet special needs.



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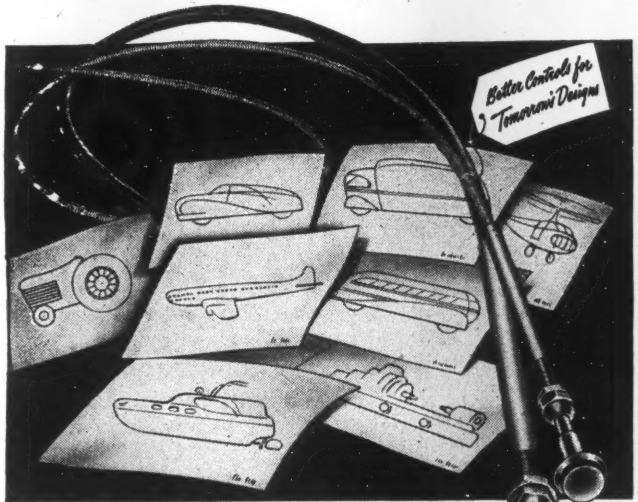
LONG DISTANCE

Eberhardt-Denver Co.
GEARS AND SPEED REDUCERS
1416 West Colfax Ave., Denver 4, Colorado Phone TAbor 7134

ARENS *Flexible*
REMOTE CONTROLS

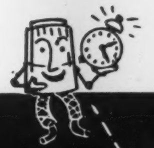


● If remote controls are a part of your present product or included in the design of your new product you can be assured of better performance with Arens Flexible or Rigid Remote Controls. Arens Controls are the result of 25 years experience in building controls to perform vital functions at maximum efficiency even under the most adverse operating conditions.

Arens also manufactures a complete line of control accessories including heads, end fittings, mounting clamps and the Arens Dura-Grom.

Write Today On Business Letterhead For Arens Catalog

ARENS CONTROLS, INC.
2257 S. Halsted Street, Chicago 8, Illinois



NOW!

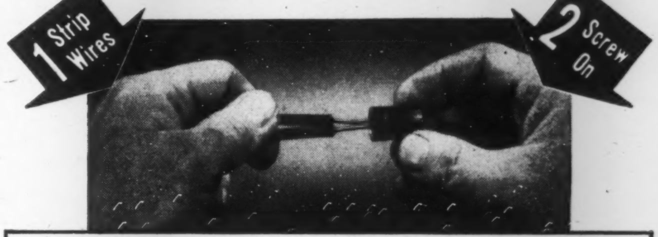
you can make wire connections in

SECONDS NOT MINUTES

with Wire-Nuts*

(THE SOLDERLESS, TAPELESS WIRE CONNECTORS)

Modern, Easy "1-2 Way"
Speeds Output Slashes Cost



Compare Your Present Method with the "IDEAL Way" and you will readily understand why so many manufacturers are using "Wire-Nuts" for low-cost, dependable connections of any usual combination of wires. No solder—no tape—no tools . . . just a twist of the wrist—like screwing a nut on a bolt. Makes a safe, compact joint—saves materials—speeds work.

STRONGER CONNECTIONS . . . Laboratory tests prove that an IDEAL "Wire-Nut" joint stands up to 3 *times* as much pull as a soldered joint.

BETTER CONNECTIONS . . . "Wire-Nut" joints have up to 25% less resistance than similar soldered joints—non-corrosive, heat and vibration resistant.

APPROVED . . . IDEAL "Wire-Nuts" are listed by Underwriters Laboratories, Inc.

Try Wire-Nuts* yourself—get FREE SAMPLES
Mail Coupon Today! No Obligation

IDEAL INDUSTRIES, Inc.
1059 Park Avenue, Sycamore, Illinois
Send Free Samples of IDEAL "Wire-Nuts" with full application and cost data.

We join____No.____wires with____No.____wires.

Name____________________

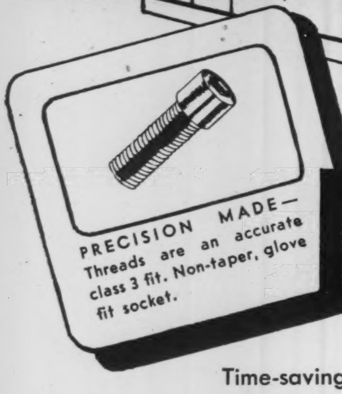
Address____________________

City__________ State__________

IDEAL
IDEAL INDUSTRIES, Inc.
Successor to
Ideal Commutator Dresser Co.
Sycamore, Ill.

*Trade Mark Reg. U.S. Pat. Off.
BUY WIRE-NUTS FROM YOUR JOBBER

production up
costs down!


PRECISION MADE—
Threads are an accurate class 3 fit. Non-taper, glove fit socket.

Blue Devil SOCKET SCREW PRODUCTS

SPECIAL ALLOY STEEL—
Scientifically heat treated for high tensile strength.

Time-saving "Blue Devil" Socket Screws are easier, more economical to use . . . facts proved time and again in thousands of production lines, shops and toolrooms. "Blue Devil" Socket Screws make easy work of difficult installations—they cut costs and speed production *everywhere!*

WIDE SELECTION of stock sizes and styles.

For the most delicate precision instruments, for large, rugged machinery, for *any* job in which you want dependable screws whose performance has been proved, specify "Blue Devil" Socket Screws.

- Socket Screws—Dardelet Thread
- Socket Screw Keys
- Socket Pipe Plugs
- Socket Set Screws
- Socket Head Cap Screws
- Socket Head Stripper Bolts

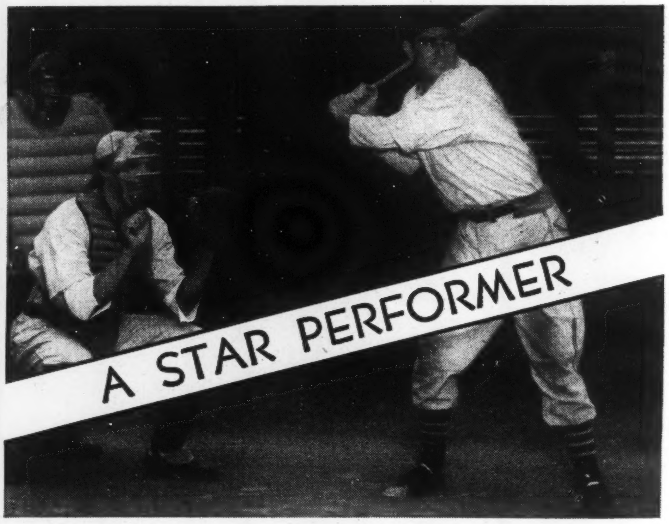
Safety Socket Screw Company
4441 N. Knox Avenue
Chicago, Illinois

Please send free catalog listing styles, sizes, prices and specifications of "Blue Devil" products.

Firm ....

Address ....

Attn. .... Title ....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Reproduces Plans . . . Quicker . . . Cheaper

NONE LIKE IT . . . FOR DIRECT BLUE LINE PRINTS

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Elliott's LIN-O-BLU Ammonia developed paper should be used by you. IT is a STAR PERFORMER everytime. Available in thin, medium or heavy weights. **WRITE DEPT. W-5 FOR FREE SAMPLES**

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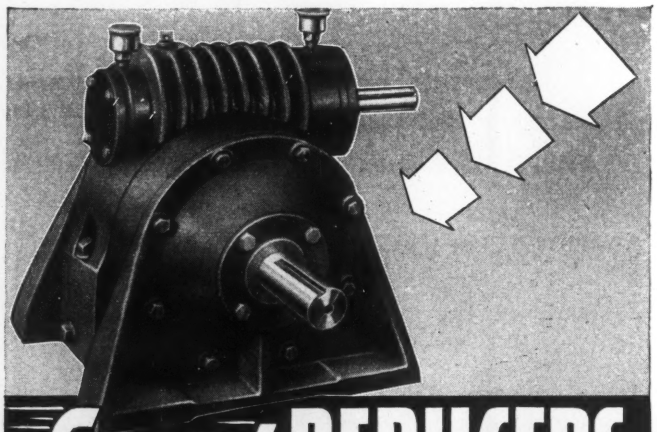


Speed REDUCERS

Do You Know . . . JANETTE Builds Both MOTORIZED and MOTORLESS SPEED REDUCERS . . . 32 styles and types of motorized and 20 motorless machines are available with foot or flange bases. ¶ Janette built motors are designed specially for driving Speed Reducers. ¶ Various types of motor enclosures, modifications, voltages, phases and speeds can be furnished. **¶ All Motors and Reducers are Built to ONE STANDARD OF QUALITY.**

Janette

1/30 to 7 1/2 H.P.
.08 to 447 R.P.M.

Janette Manufacturing Company
556 W. Monroe St. Chicago 6, Ill.

C-1113

A LOW CARBON FREE-MACHINING OPEN-HEARTH STEEL

DESIGN FOR MACHINABILITY

C-1144

A MEDIUM CARBON FREE-MACHINING OPEN-HEARTH STEEL

Specify these modern sulphurized steels for vital machine parts. They will provide the sturdy service qualities of open-hearth with the *plus* advantage of economy in fabrication due to their free-machining characteristics.

C-1113 is a versatile screw stock suited for parts that require high-speed machining, carburizing and hardening, as well as minor cold forming, such as crimping or bending . . . and it machines faster than B-1112.

C-1144 is an economical screw machine steel of extremely high machinability, ideally suited for flame and induction hardened applications. It is also satisfactory for conventional heat treatment . . . and when superficially hardened, C-1144 may sometimes be substituted for carburized steels.

Write for descriptive folders on these steels

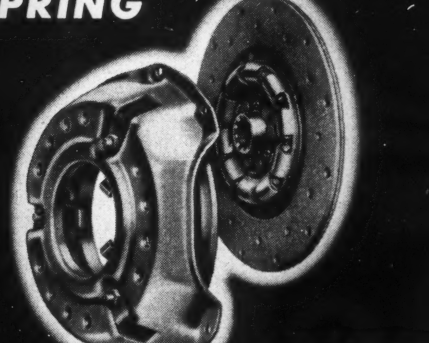
BLISS & LAUGHLIN, INC.

HARVEY, ILL. • BUFFALO, N. Y. • MANSFIELD, MASS.

Sales Offices in all Principal Cities

Cold Finished Bar Steels and Shafting

ROCKFORD SPRING LOADED CLUTCHES



LIGHT PEDAL PRESSURE
CUSHIONED ENGAGEMENT
VIBRATION DAMPENING
ACCURATE BALANCE
DIRT EXCLUSION *
HEAT DISSIPATION
LIFETIME ADJUSTMENT

* The life of ROCKFORD Spring Loaded CLUTCHES is lengthened by the design of their cover plates. This feature provides maximum ventilation for the clutch. The openings in the top and sides supply a flow of air that promotes cooling and the escape of dirt and dust from the clutch. This life-lengthening cover design is just one of several ROCKFORD advantages.

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Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD CLUTCH DIVISION BORG-WARNER
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Every conceivable type of Socket and Jewel Light Assembly is available at DRAKE . . all measuring up to the same high quality standards. If a new application calls for a special design, our skilled engineers will work with you to design a unit to meet your specific needs. DRAKE quality, dependability, and patented features are widely known and appreciated among those who know Socket and Jewel Assemblies best. Large production facilities assure reasonably prompt deliveries in any quantity. Write or wire for samples and full information.

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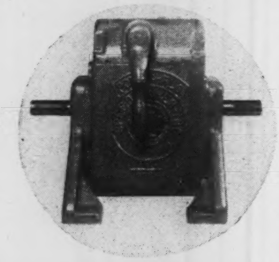
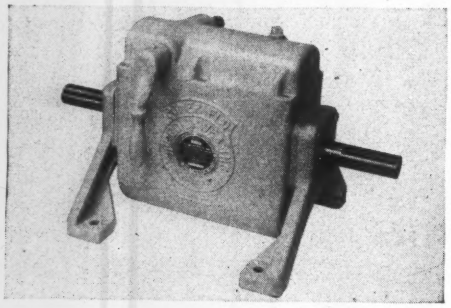
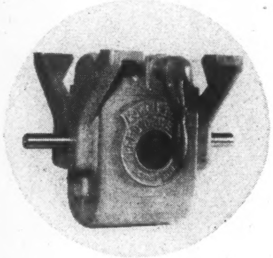
Socket and Jewel LIGHT ASSEMBLIES

DRAKE MANUFACTURING CO.
1713 W. HUBBARD ST. • CHICAGO 22

POWER-FLO
MACHINE DRIVES

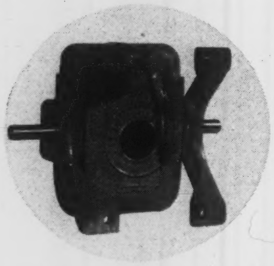


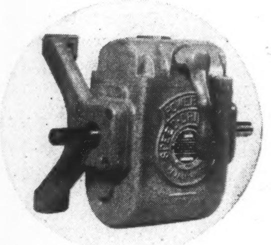




- ★ BELL-END MOUNTING
- ★ ANTI-FRICTION BEARINGS
- ★ HARDENED GEARS & SHAFTS

- ★ LEAK PROOF OIL SEALS
- ★ SPRING LOCKED SHIFTING
- ★ SPLASH-BATH LUBRICATION





Precision Built

1/2 HP——TO——20 HP
SPEED RATIOS 1:1, 1-3/4:1, 3:1, 4:1
CLUTCH MODELS AVAILABLE FROM
3 TO 10 H.P.
DETAILED SPECIFICATIONS
AVAILABLE TO MACHINE DESIGNERS
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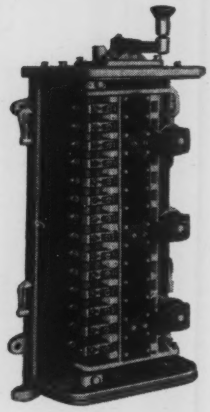
P. O. BOX 303

EUCLID A.C. and D.C.
DRUM CONTROLLERS



are built for Heavy Duty Service on Cranes, Hoists and Electric Trucks

4, 6, 7, 8 & 9 Speeds
2 and 3 Pole

With or Without Main Line Limit Switch Connections

Operation by rotary handle, rope wheel and guard, or geared lever.

Illustrated above is the Type DSD-2850 D.C. Dynamic Lowering Drum Controller. This controller like other Euclid drum controllers includes renewable and reversible finger tips and drum segments for longer contact life. Patented "inside loop" contact springs are used for easy inspection and maintenance of contacts.

Write for Bulletin 1012 MD

THE EUCLID ELECTRIC & MFG. CO.
1335 CHARDON RD. EUCLID 17, OHIO

Your MOBILE Products Deserve the BEST

WHEELS

for FARM

for INDUSTRY

WE EXTEND to all manufacturers of mobile farm equipment the full benefits of our capacity for designing, testing and producing wheels capable of satisfying, in full, the actual demands of any given range of field service. In many instances it may be possible to utilize STANDARD WHEELS and HUBS — thereby achieving economies and avoiding delays.

Send Your Wheel Problems to Us

FRENCH & HECHT
DIVISION
KELSEY-HAYES WHEEL COMPANY
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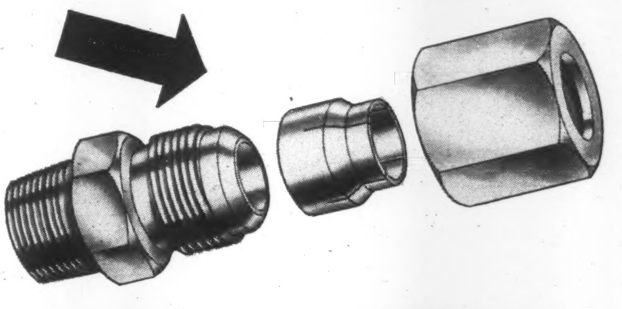
Wheel Builders

Since 1888



THE GRIP TUBE STEEL SPRING SLEEVE SEALS HIGHER FLUID PRESSURES

Absorb tube vibrations, seal higher fluid pressures, avoid increased cost of installation and service with Grip Tube Fittings.

The spring steel sleeve of Grip Tube Fittings will not jam within the nut and may be reused repeatedly. The sleeve protects the flare and resiliency supports the tube against vibration.

Available in Straight—Union—Elbow—Side Tee—Tube Tee and Cross, both male and female. Sizes from ¼" to 1½".

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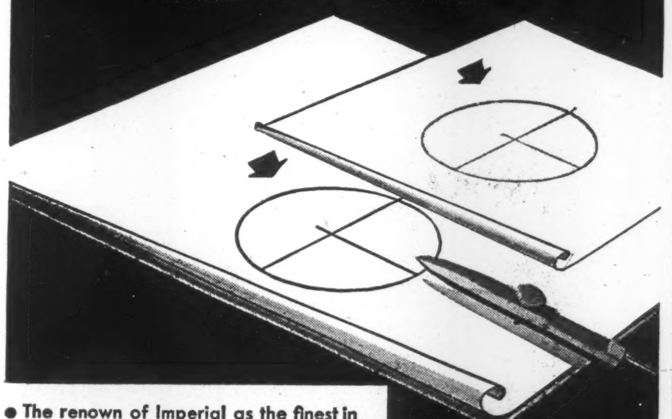
Flodar Corporation
331 Frankfort Ave. Cleveland 11, Ohio

TRACING CLOTH THAT DEFIES TIME



● The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

IMPERIAL TRACING CLOTH

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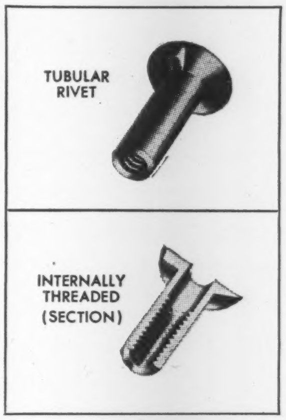
Wichita City Libr

SOLVE FASTENING PROBLEMS

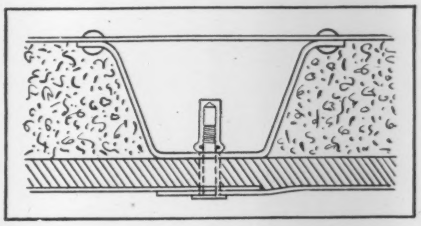
Quickly . . . Easily with RIVNUTS

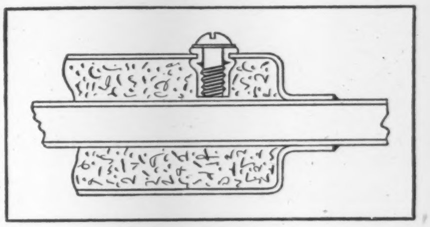


Rivnuts are an easy, practical answer to many tough fastening problems. They fasten with...they fasten to...or both! Entire operation is completed from *one side only.* Simply, quickly installed and headed with an easy-to-handle tool, B. F. Goodrich Rivnuts form a compression fit, have an unusually wide bearing surface, and require only a small hole. Rivnuts are light, strong, and ready for use as received in steel, aluminum, brass, or splined aluminum. Perhaps they can answer your fastening problem.

How RIVNUTS *Answered Two Tough Problems*

Used as a rivet in refrigerator trucks, a BR 6-380 (or BR 6B-380) Rivnut with spacer head was inserted and headed. Splice and hole in Rivnut were then soldered, making a fast, firm attachment.

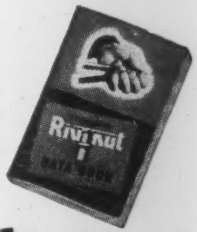




Used as a filler plug for a line oiler, an S 25-80 Rivnut received a standard screw and fiber washer. Installation was leakproof because Rivnut formed a compression fit.

Free "RIVNUT DATA BOOK"

40 fact-packed pages of the whole Rivnut story. Clearly illustrated in step-by-step style. Data on types, sizes, strength, grip ranges, tools and tests. Write now for your copy to The B. F. Goodrich Company, Dept. MD-47, Akron, Ohio.



B.F. Goodrich
RIVNUTS

It's a rivet—It's a nutplate

ALLEN

FLAT HEAD CAP SCREWS

Check these advantages with your *flush fastening* requirements, *and call your local Allen* Distributor: (1) Flush top surface with no gap between screw head and surrounding metal. (2) Extreme rigidity of grip, because angle of head helps lock screw in place by drawing down on a conical surface. (3) Firmer hold on thin plates of metal, by more binding surface under the head than in fillister type or cheese-head screws. (4) Shallower countersink — less weakening of metal — when used for fastening a relatively thin plate. (5) Positive engagement of hex key transmits power for tightest of set-ups without slipping, reaming or side play. (6) Maximum strength of screw itself assured by *"pressur-forming"* of special-analysis ALLENOY steel. Threaded to a high Class 3 fit. (7) Speed in assembly provided for by use of Allen hand drivers.

THE ALLEN MFG. CO.
Hartford 1, Conn.

EXPANDING
range of applications
FOR DEPENDABLE FLUSH FASTENINGS

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a skilled hand *guides every operation* on Fairfield gears

Truly fine gears are the product of manufacturing skill and fine equipment. Fairfield offers both—over 25 years of fine gear-making experience and batteries of modern gear-making machines. Here are complete facilities for making fine gears to order with each operation under the supervision of a skilled craftsman.

Let us go over your gear problems with you. Write for complete information on what Fairfield can do for you. Fairfield Manufacturing Co. 311 South Earl Avenue, Lafayette, Indiana.

Here are a few of the industries for which Fairfield supplies fine gears *made to order*

Automotive • Construction Machinery • Agricultural Machinery Aviation Equipment • Mining Machinery • Machine Tools • Oil Field Machinery • Marine Equipment • Pumps and Winches • Transportation

FAIRFIELD *For FINE GEARS*

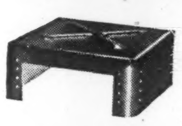
EWC WHEELS

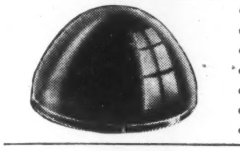
Engineered for YOUR Product

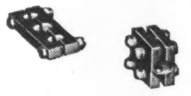
There is a wide variety of EWC wheels and axles for every type of mobile equipment . . . one or several may be ideally suited to your product. For unusual wheel problems, we offer you a complete engineering service, with a thoroughly experienced staff and unexcelled facilities. Write today for complete information.

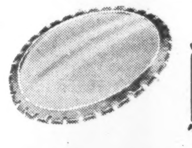
ELECTRIC WHEEL CO., Quincy, Illinois, Est. 1890

...... here is PLASTIC FABRICATION engineered to your specifications









If your specifications call for strength and durability coupled with lightness in weight, better consider plastics. You get these advantages plus color, high visibility, beauty and good dielectric properties . . . with parts and assemblies held to surprisingly close tolerances. Plastics are versatile and Fabri-Form engineers can quickly choose the type best suited to your product or problem.

Plastics fabrication offers unlimited uses in all manner of shapes and forms. With Fabri-Form the entire job is worked out . . . from basic design through final production. Complete laboratory facilities are available for research and experimental projects . . . where experienced plastics engineers are constantly working to improve techniques and methods.

We *know* how plastic fabrication can be utilized to do a better job . . . to improve appearance and give you a better product . . . and often to reduce costs. Manufacturers of precision instruments, aircraft, boats, electrical goods, heavy machinery, automotive parts and accessories are but a few who have used and profited by our complete plastic fabrication and forming service.

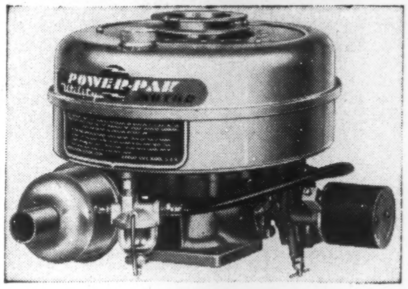
Write today for facts on how plastics can be put to work for *you*. Ask for folder "Custom Fabrication In Plastics." M

PLASTICS FABRICATORS

THE *Fabri-Form* CO.
108 Seneca St. Byesville, Ohio

Power It with...
POWER-PAK
GASOLINE UTILITY MOTOR

- **2 hp. at 4000 rpm.**
- **Precision-Built**
- **Light Weight**
- **Compact**
- **Rugged**



DESIGNED TO MEET MODERN DEMANDS!

*H*ere's a modern-to-the-minute, precision-built, gasoline motor especially fitted to the needs of industrial designers and manufacturers making machines and equipment requiring 2 H.P.

POWER-PAK is compactly designed, light weight (only 19 lbs.), every piece and part of finest materials to insure long, smooth, trouble-free operation. Overall length 14⅜", width of cowling 9½", height 8$\frac{11}{16}$". Easily installed . . . economical on fuel . . . easy access to all vital parts. Replacement parts always in stock. Let POWER-PAK solve your power problem.

AVAILABLE NOW . . . GET FULL FACTS

Write today for Illustrated Literature, full details and prices on the POWER-PAK.

PROPULSION ENGINE CORP.
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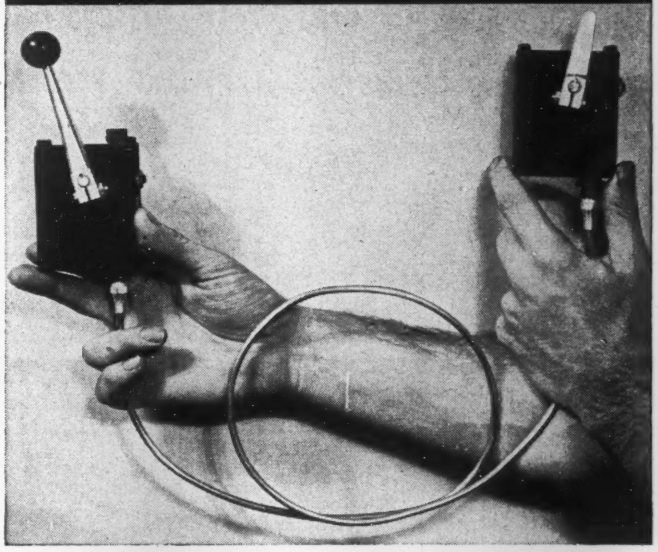
SPERRY
Single Tube HYDRAULIC SYSTEMS



Here's a tiny — almost miniature — Sperry Control System that's:

EASY-TO-INSTALL
A single flexible copper tube connects receiver and transmitter... does away with design limitations imposed by use of old-fashioned link rods and bell cranks, pulleys and control cables, etc.

EASY-TO-OPERATE
Balanced system permits operation with fingertip pressure — smooth, even action without time lag, without backlash.

ACCURATE AND DEPENDABLE
Accuracy of ¼ of 1 degree through an effective operating arc of 60°. Water-proof, corrosion-resistant, dust-proof, it's as dependable as the larger units long manufactured by Sperry.

Write for Bulletin 2400-B or for information on your particular problem. SP-102

Dealer Inquiries are also invited.

SPERRY

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15th Street & Willow Avenue
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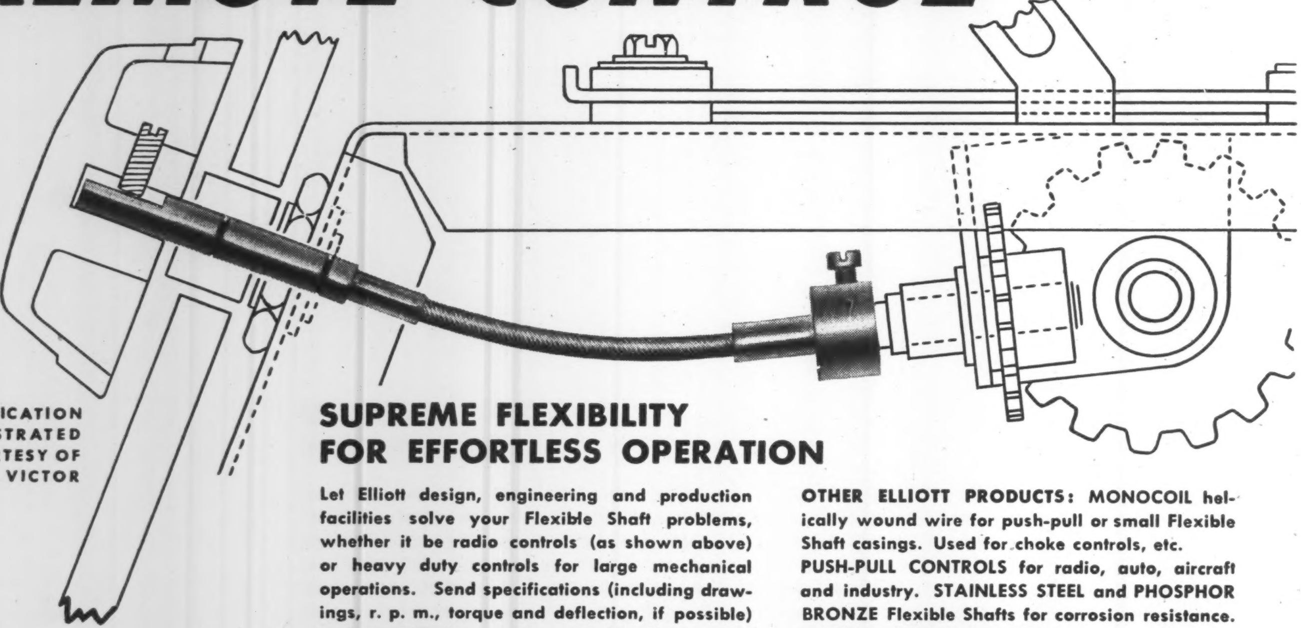
REMOTE CONTROL BY ELLIOTT



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SUPREME FLEXIBILITY FOR EFFORTLESS OPERATION

Let Elliott design, engineering and production facilities solve your Flexible Shaft problems, whether it be radio controls (as shown above) or heavy duty controls for large mechanical operations. Send specifications (including drawings, r. p. m., torque and deflection, if possible) and we will give you our recommendations and quote prices.

OTHER ELLIOTT PRODUCTS: MONOCOIL helically wound wire for push-pull or small Flexible Shaft casings. Used for choke controls, etc. PUSH-PULL CONTROLS for radio, auto, aircraft and industry. STAINLESS STEEL and PHOSPHOR BRONZE Flexible Shafts for corrosion resistance. FLEXIBLE SHAFT ASSEMBLIES of all types for power and remote controls.

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★ FLEXIBLE SHAFTS FOR POWER DRIVES AND REMOTE CONTROLS ★

Why "SEALOL"?

EXACTING DESIGN ENGINEERS USE "SEALOL" BECAUSE:

1 "Sealol" is compact, long-lived, reliable.
2 Balanced Pressure design controls seal face pressure; minimizes frictional heating.
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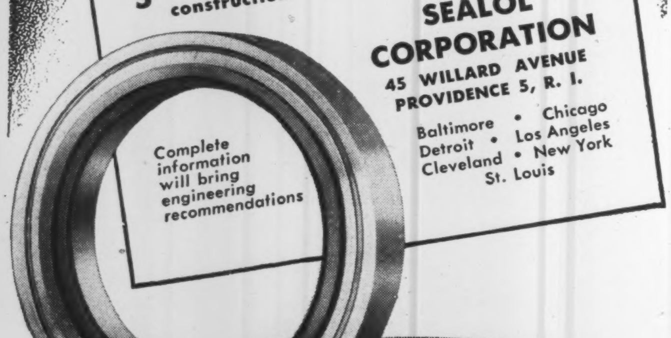
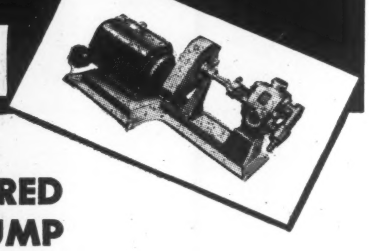


Complete information will bring engineering recommendations

Viking



THE PREFERRED ROTARY PUMP

In The Industrial Field

A recent nation-wide survey showed decisively the wide popularity of Viking Rotary Pumps in the industrial field. Why this preference? The answer is simple.

Viking Rotary Pumps do a dependable job because they are simple . . . just 2 moving parts . . . each self-supported. They operate at low speed, which provides longer, trouble-free life. There are no gadgets, springs or timing gears to get out of order. They are self-priming . . . move the liquid without pulsation.

Write today for Bulletin Series 46SH. It will be sent to you by return mail.

See Our Catalog In SWEETS

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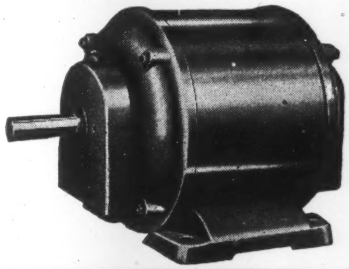
CEDAR FALLS, IOWA

Design Engineers Specify

VALLEY
Ball Bearing
MOTORS

Because -

- They offer more flexibility in power planning.
- They are built to meet unusual power loads and high temperatures.
- They meet all operating conditions where hazards of liquids, chips, etc., dropping into the motor are involved; as well as splash conditions.
- Being made in ½ to 75 h. p. sizes, they offer wide adaptability.



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ELECTRIC CORPORATION
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THERE'S MORE TO THIS THAN MEETS THE EYE...IT'S

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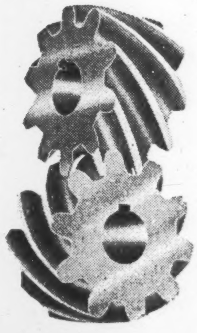
To provide the maximum in gear efficiency, CINCINNATI GEARS, where needed, are ground, lapped or shaved. We can shave from 1" to 24" pitch diameter.

In thousands of applications, Cincinnati GEARS, GOOD GEARS ONLY, are proving their unique fitness in meeting engineering demands for precision and performance.



THE CINCINNATI GEAR COMPANY
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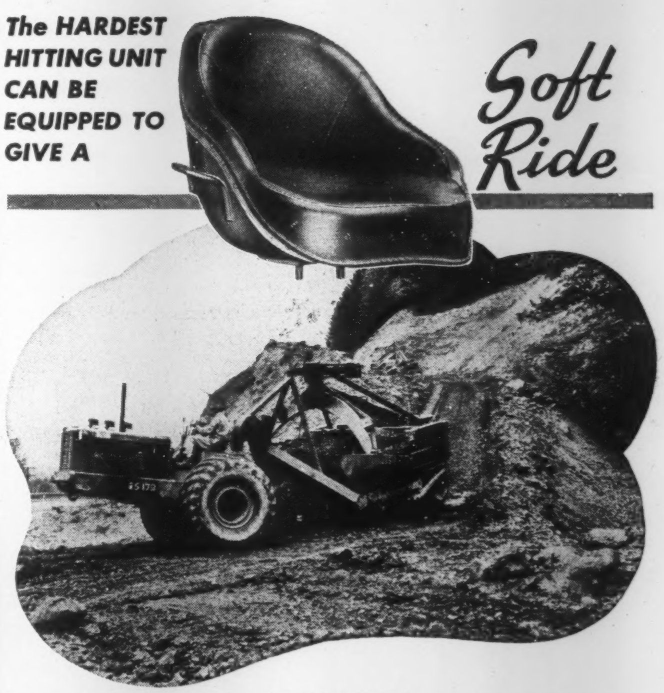
The HARDEST HITTING UNIT CAN BE EQUIPPED TO GIVE A

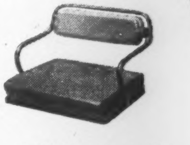


THE FAMOUS TOURNAPULL EARTH MOVER IS MILSCO CUSHION SEAT EQUIPPED

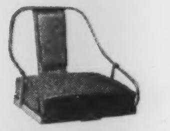
THE big, two-wheeled, rubber-tired, high-speed earthmoving TOURNAPULL, made by R. G. Le Tourneau, Inc., Peoria, Illinois, is a machine with an impressive record for job performance. Because it is designed for rapid acceleration to top speed and fast spreading over rough and tough as well as even terrain, *operator comfort* is an important factor in its performance. That factor is fully provided for by a MILSCO designed and engineered cushion seat (De Luxe Type No. 783).

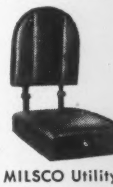
Here is a typical example of the *cushion seat know-how* the MILSCO organization of specialists is qualified to render equipment manufacturers. Whether the problem calls for providing seat comfort for a light weight mobile material handling unit or a heavy hitting earth mover, MILSCO can solve your seating problems economically. Write today for the specialized information MILSCO can give on quality-made cushion seats to meet your cost requirements.

STANDARDIZED Milsco MILWAUKEE **TYPES . . .**

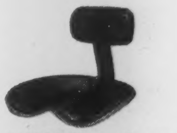

MILSCO Commander Type

MILSCO Semi-Bucket Type


MILSCO Crusader Type

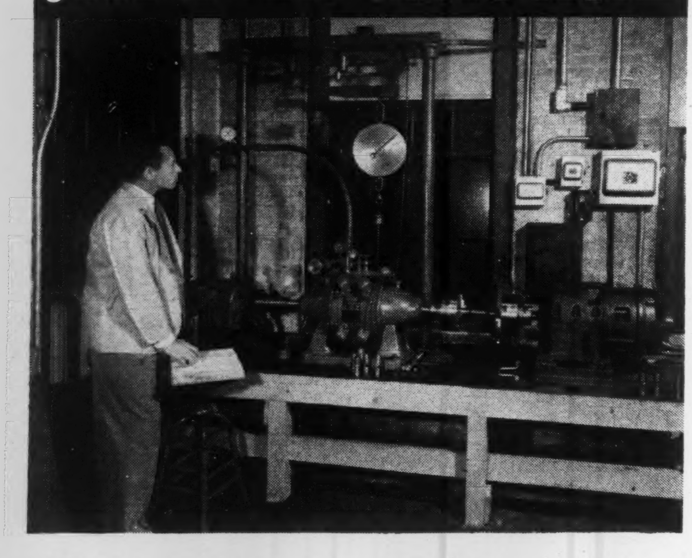

MILSCO Utility Type

MILSCO Bucket Type


MILSCO Bucket Type with backrest

MILSCO MANUFACTURING COMPANY
2758-C N. 33RD STREET, MILWAUKEE 10, WIS.

JUST A FEW CENTS MORE



But What a Difference

IN • WHAT • YOU • GET!!

Yes, a Curtis Universal Joint may cost a few cents more than other joints, but the smart designer or engineer **knows** the difference in the service delivered by Curtis Joints.

Machined from special alloy steel bars, not forged, the hubs of our joints are the same diameter throughout — giving uniform strength at all points. Compact, with greater strength, Curtis industrial type joints of a smaller size can many times replace larger, more cumbersome joints. A glance at our Engineering Data Chart showing breaking loads by joint sizes will convince any engineer.

In addition, Curtis forks, centerblocks and pins are all heat treated for maximum toughness. Pin holes are broached and honed for perfect alignment — pins are centerless ground to close tolerance to reduce radial play — center blocks are precision ground for long wear with special oil grooves to permit adequate lubrication. Patented "Telltale" lock ring insures positive lockup of entire assembly and visible end shows ring is in proper locking position.

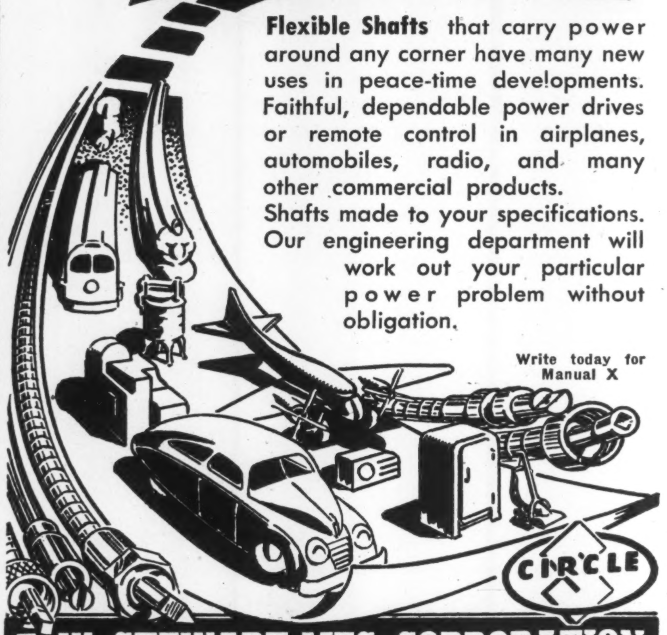
All this **means** smoother, longer life with lower maintenance cost — for just a few cents more per joint.

Specify **Curtis Universal Joints** always — Write for Engineering Data and useful Templates.

DEPT. B

CURTIS UNIVERSAL JOINT CO. INC. SPRINGFIELD MASS.

FLEXIBLE SHAFTS



Flexible Shafts that carry power around any corner have many new uses in peace-time developments. Faithful, dependable power drives or remote control in airplanes, automobiles, radio, and many other commercial products.
Shafts made to your specifications. Our engineering department will work out your particular power problem without obligation.

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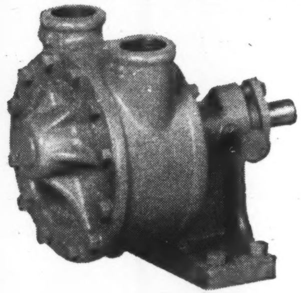
LONG ON SERVICE . . . SHORT ON COST

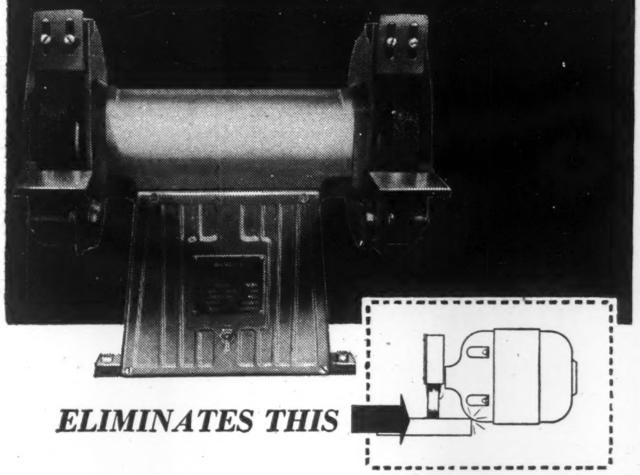


It Pays to Specify TUTHILL Model C for General Purpose Pumps

Low in first cost and engineered for long service with negligible maintenance, Tuthill Model C pumps are outstanding in general service on non-corrosive liquids. Compact and built for rugged service, these internal-gear rotary pumps operate efficiently in either rotation. Capacities from 1 to 200 g.p.m. at pressures up to 100 p.s.i. Direct drive, belt drive, V-belt units and stripped models available. Write for Model C bulletin.

TUTHILL PUMP COMPANY
939 East 95th Street • Chicago 19, Illinois

NEW Bardco FULL-CLEARANCE GRINDER



ELIMINATES THIS

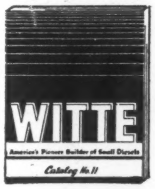
The special, small-diameter motor of the Bardco grinder does not project into the working area. You have a clear, unobstructed working space between grinding wheels. Also, because this space is clear, the entire grit portion of the wheel can be used, right down to the retaining rings.

7", 8", and 10" models are available cast-aluminum base

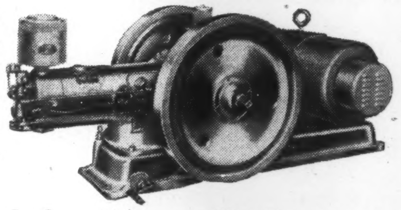
Send for descriptive literature

ELECTRIC BARDCO POWER MFG. and SALES CO.
2450 E. 23rd Street, Los Angeles, California

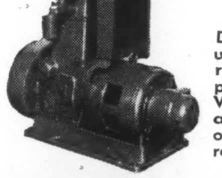
Guard the Performance Ability of Your Machine—Power it with a WITTE Diesel Unit . . .



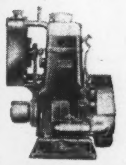
Coupling the careful design of your machine with careful selection of its powering unit, you will find there is a dependable WITTE Dieselectric Plant or WITTE Diesel Engine to precisely fill your needs. Ordinary Diesel fuel, readily obtainable everywhere, starts and operates both vertical and horizontal models. Sturdy, compact, simple, these powering units occupy little floor space and are safe for operation in confined places. Shipped complete, ready for use.



Ideal for Export Markets, too



Export markets insist upon Diesel power; WITTE Diesel units are *full* Diesels, smooth-running, and known for dependability around the world. Write for new WITTE catalog and specific recommendations of WITTE engineers on your requirements.



WITTE ENGINE WORKS
DIVISION OF OIL WELL SUPPLY COMPANY USS UNITED STATES STEEL CORPORATION SUBSIDIARY
AMERICA'S PIONEER BUILDER OF SMALL DIESELS KANSAS CITY 3, MO., U.S.A.

Look to Lewellen

employ the pioneer in speed control to solve your problem!

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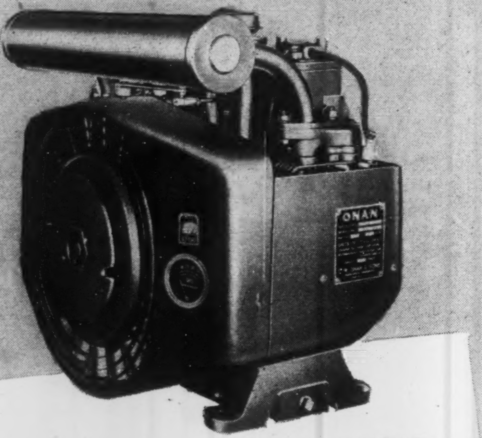
LEWELLEN MFG. CO.
Columbus, Indiana

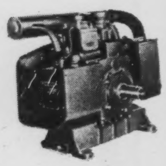
LEWELLEN
Variable-Speed
TRANSMISSIONS - MOTOR PULLEYS

SMOOTH POWER

Two-Cylinder

The NEW ONAN AIR-COOLED "CK" ENGINE 10 H. P. 4-CYCLE





Two-cylinder horizontal opposed design gives the new, heavy-duty CK engine unusual running smoothness. Short, rigid crankshaft . . . 2-inch diameter main and 1⅝-inch diameter rod bearings . . . pressure lubrication . . . axial-flow cooling fan . . . aluminum construction giving 4-to-1 cooling advantage over cast iron . . . weighs only 97 pounds and fits neatly into 15″ x 19″ x 18″ space. Designed to solve engine power problems in industry, agriculture and other fields. Proven by thousands in use today . . . now in mass production . . . prompt delivery.

Also has: Built-in precision governor . . . downdraft concentric carburetor for wide-angle operation . . . oil bath air cleaner . . . fuel pump . . . oil pressure gauge . . . crankcase fumes exhausted to carburetor . . . hermetically sealed magneto ignition coil with easy-to-get-at breaker points, 2-qt. oil capacity.

ONAN ELECTRIC PLANTS—A.C.—350 to 35,000 watts in standard voltages and frequencies; D.C.—600 to 10,000 watts, 115 and 230 volts. Battery chargers—500 to 3,500 watts, 6 to 115 volts.

ONAN AIR-COOLED ENGINES—CK: 2-cylinder opposed, 10 h.p.; BH: 2-cylinder opposed, 5.5 h.p.; 1B: 1-cylinder, 2.5 h.p.

Electric Starting

Built-in electric push-button or automatic starting is optional; adds little to overall dimensions. ⇨

WRITE FOR COMPLETE SPECIFICATIONS

D. W. ONAN & SONS INC.
4335 Royalston Ave.
Minneapolis 5, Minn.

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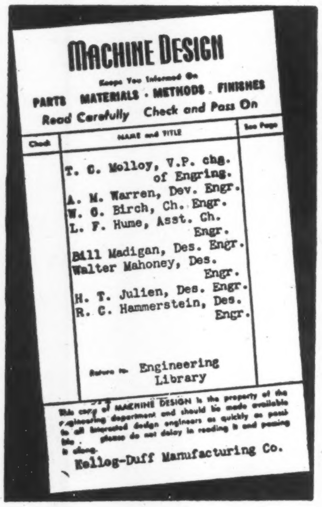
ONAN *4-Cycle* ENGINES

Routing Slips

MAKE MACHINE DESIGN AVAILABLE TO ADDITIONAL DESIGN ENGINEERS



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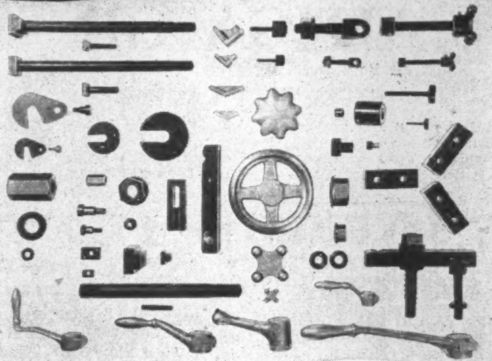

Jergens Standard Accessories cut costs . . . save time! This complete line of precision units enables tool engineers to design faster . . . to build better at lower cost! Jergens parts are engineered to highest standards for maximum efficiency. Available for immediate shipment. Write for Catalog containing templates of all items and Price List.

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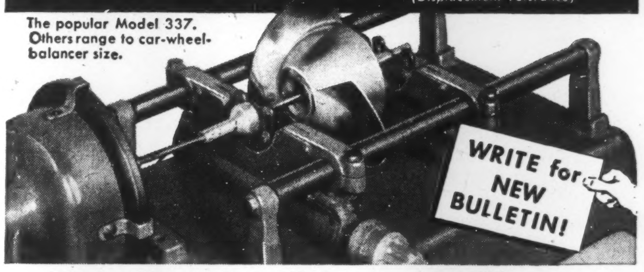
712 E. 163rd ST. • CLEVELAND 10, OHIO

20 per HOUR to 3 MILS!
(Displacement Tolerance)

The popular Model 337. Others range to car-wheel-balancer size.



How One Manufacturer Profits by BEAR DY-NAMIC BALANCING

Reports the Dynamic Air Engineering Co. of Los Angeles: "Bear eliminates the "Wobblies" of un-balance in high speed axial flow propellers faster than 20 per hour to a 3 mil displacement tolerance." Here, as always, the Bear machine is so small in size, and so quick, that the operation fits readily into production.

Any shop hand can learn Bear-Balancing in less than a day. Every Bear machine is widely adaptable within its range. Each balances bodies to the recognized standards. All are very reasonably priced. Write for new literature . . . chase the "Wobblies," of dy-namic and static un-balance . . . improve both product and sales! BEAR MFG. CO., Industrial Div., Dept. M-4, Rock Island, Ill. 1771

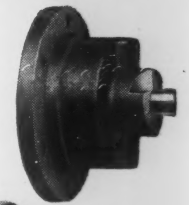
BEAR
COMBINATION
STATIC AND DY-NAMIC BALANCING MACHINES

SPECIAL PUMPS FOR YOUR SPECIAL PURPOSES

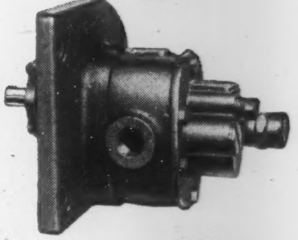
Here are just a few of the many special pumps manufactured by Brown & Sharpe . . . to do special jobs in many different fields. Besides making pumps with various mountings we make pumps with special internal construction to fit individual requirements . . . often from stock parts. Write us *YOUR* specifications and also ask for complete catalog of stock pumps. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

Flange Mounted Rotary Geared Pump readily adapted to many machines.

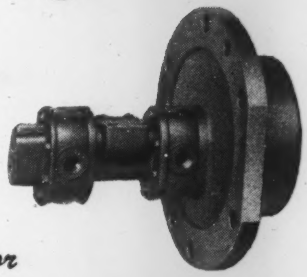
This Vane Pump with Flange Mounting fits easily into many designs.



Rotary Geared Pump designed for lubrication of Diesel Engines.



Duplex Unit with Flange Mounting. The two pumps, coupled by a flexible drive, can be separated by a suitable seal to pump dissimilar liquids.



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Arkwright gives you the kind of surface that practically assures razor-sharp lines. Oil, wax and soap-free mechanical processing assures uniform capillarity. Even the weaving and bleaching of special cloth is part of Arkwright's exhaustive system of standards, tests and inspections—to *prevent* pinholes, thick threads and the many other things that cause spoiled tracings, lost time.

Why not try Arkwright and see for yourself what a difference there is? Send for free working samples. Arkwright Finishing Company, Providence, R. I.

All Arkwright Tracing Cloths have these 6 important advantages

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5. *No pinholes or thick threads*
6. *Mechanical processing creates permanent transparency*

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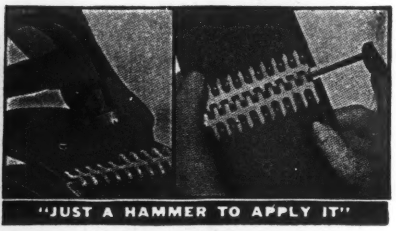

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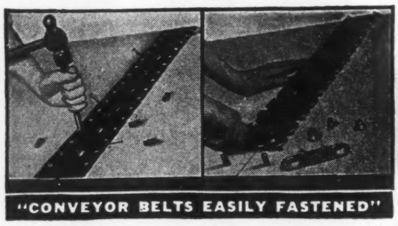

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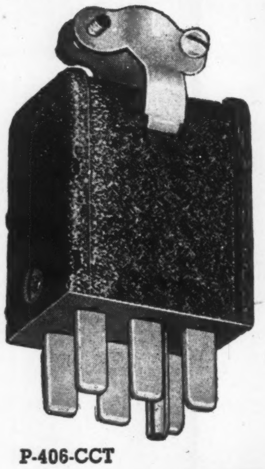

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A medium size Plug and Socket that fulfills practically every requirement in the Public Address, Radio and kindred fields. Socket Contacts are of the "knife-switch" type of phosphor bronze, cadmium plated.

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Made in 2, 4, 6, 8, 10 and 12 Contacts.

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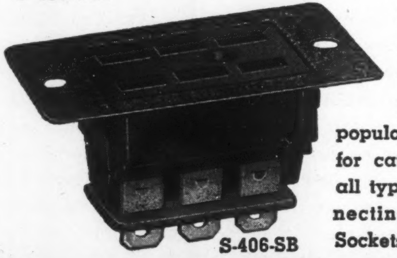

S-406-SB

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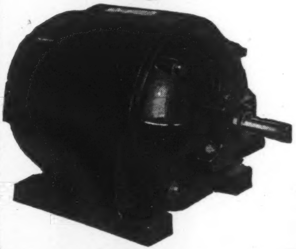

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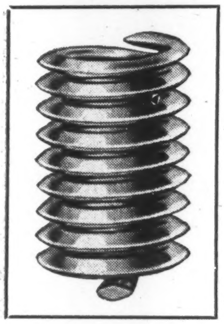

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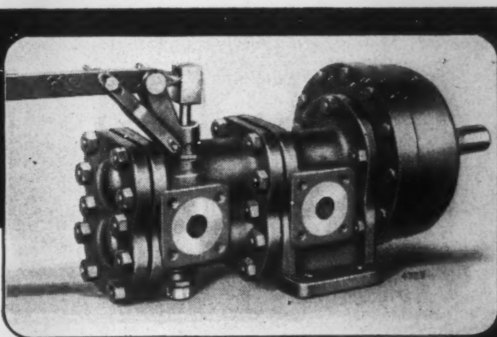

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IMO means I MOVE OIL

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PICTURE QUIZ: Which of these five people gives the right reason for buying U.S. Bonds?

(ANSWER BELOW)

1. **Easy to save!** "I'm putting my money into U. S. Bonds because it's the *easiest way* for me to save. Under the Payroll Savings Plan, I put aside a regular amount each week for Bonds. So far, I've saved $500 without missing the money!"

2. **Good investment!** "Getting back $4 for every $3 I invest—the way I will in ten years' time with U. S. Bonds—is my idea of a *good investment.* I know it's safe and sound, too, because it's backed by Uncle Sam. Buy Bonds, I say."

3. **Plans for the future!** "Ten years from now, the money I'll get for my U.S. Bonds will help to send my kids to college, or buy our family a new home. I think that buying U. S. Bonds is the wisest thing a family man can do."

4. **Fights inflation!** "I want America to stay economically sound. That's why I'm putting all our extra dollars into U. S. Bonds. It's like buying a share in our country's future prosperity!"

5. **Rainy day!** "Maybe a rainy day's coming for me. Maybe it isn't. But I am taking no chances. That's why I'm buying all the U. S. Bonds I can through my Payroll Savings Plan."

THE ANSWER

Every one of these people gives the "right" reason—because there's more than one right reason for buying U. S. Bonds.

Whichever way you buy them—through Payroll Savings, or your local bank or post office—U.S. Bonds are the best investment you can make!

Save the *easy* way..buy *your* bonds through payroll savings

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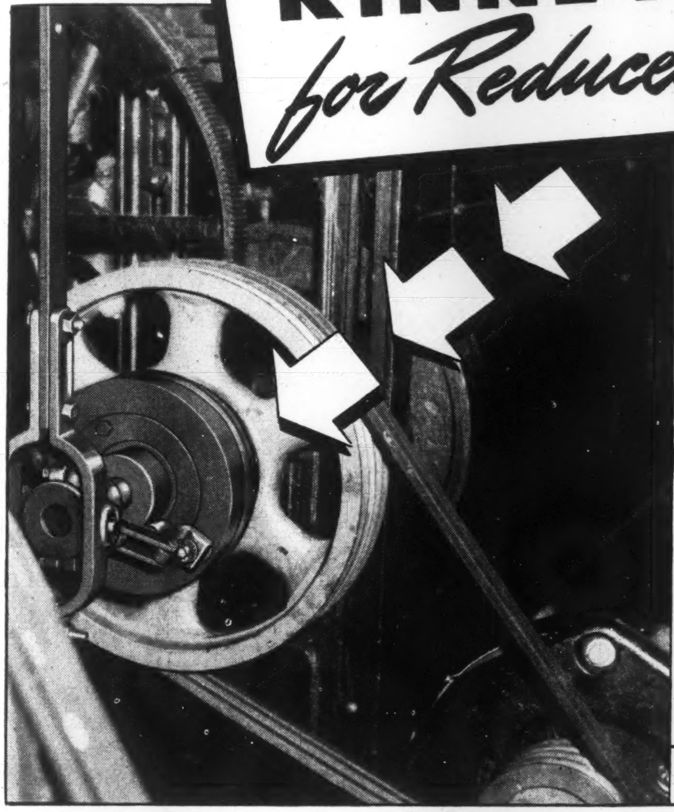

Individual motor drive with Kinney Interchange Clutches helps busy machines operate at top efficiency. The clutch, when disengaged, allows the motor to come up to speed without load and permits the use of a small, economical motor just large enough to run the equipment. The Kinney Clutch engages smoothly, with ample slippage to absorb a heavy starting load and the rugged toggle mechanism locks the friction plates together when fully engaged. All power is transmitted through flat discs and *not* through bolts or shifting mechanism. Kinney Interchange Clutches are available in solid or split construction for easy installation, with capacities 2 to 40 H.P. per 100 r.p.m.

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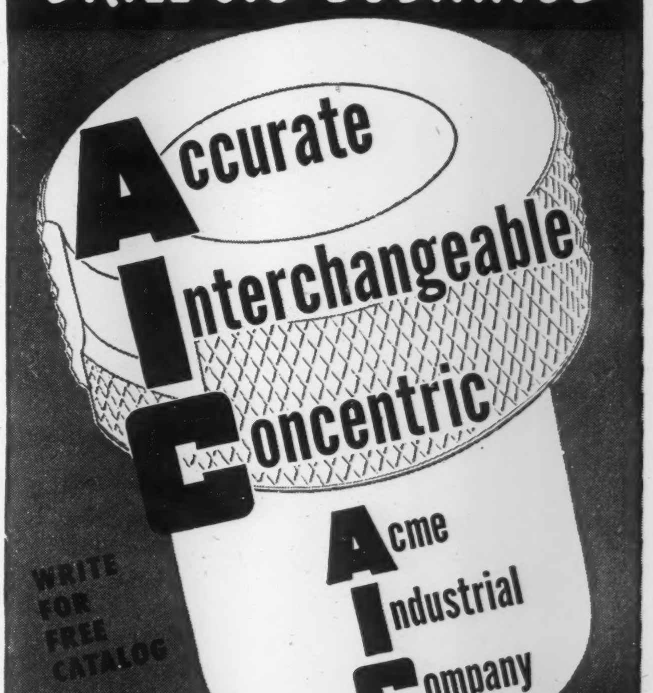

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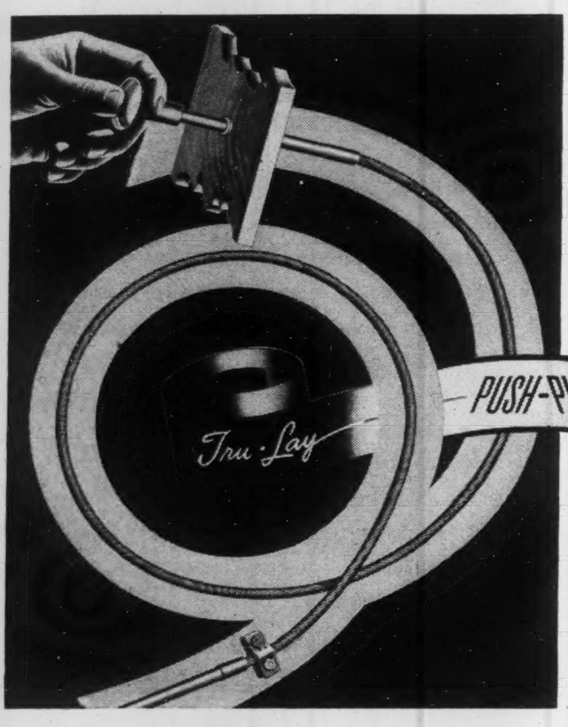

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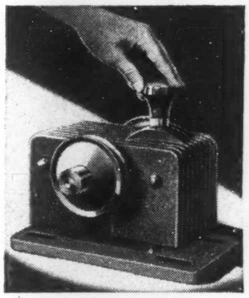

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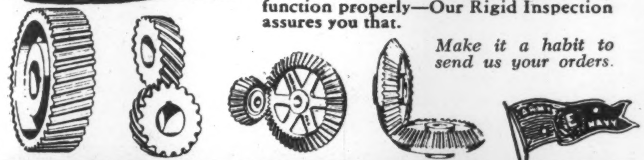

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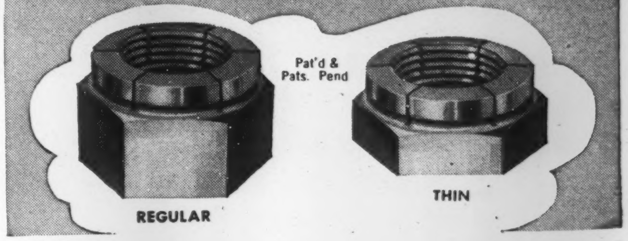
FLEXLOC



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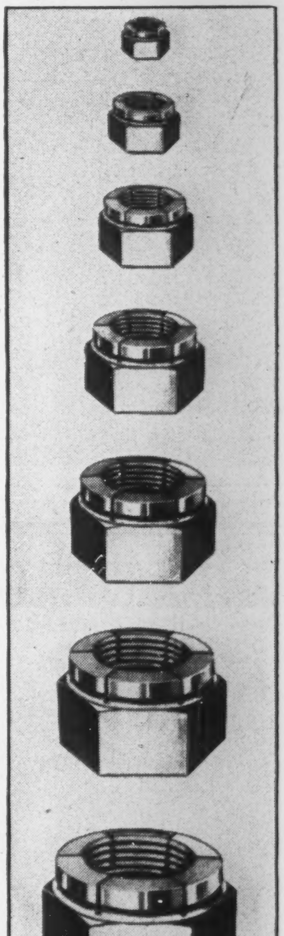

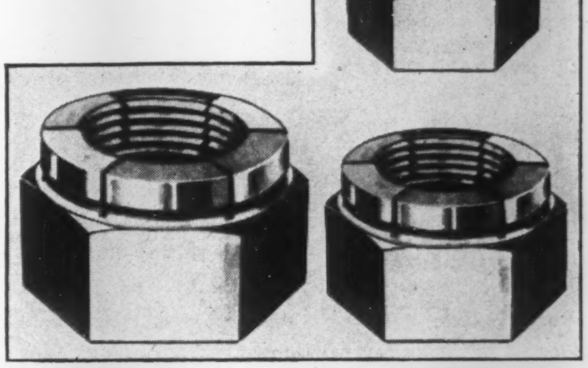

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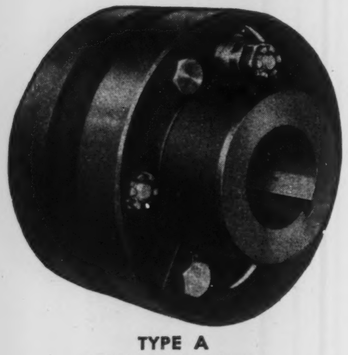

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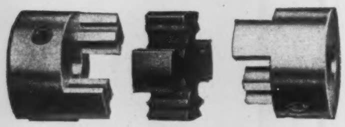

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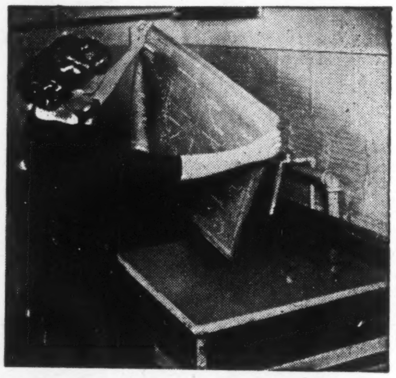

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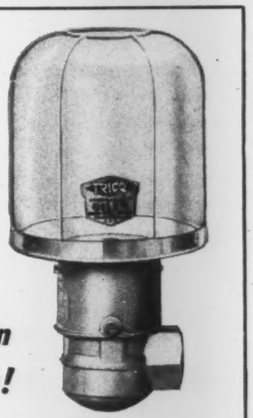

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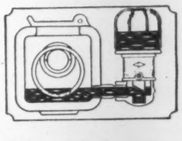

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- Thorough bearing protection
- Greater machine life
- Added prestige.

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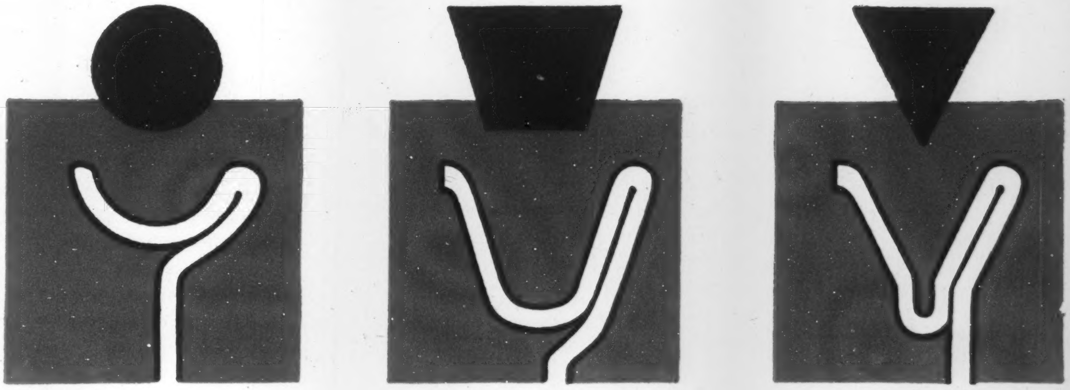
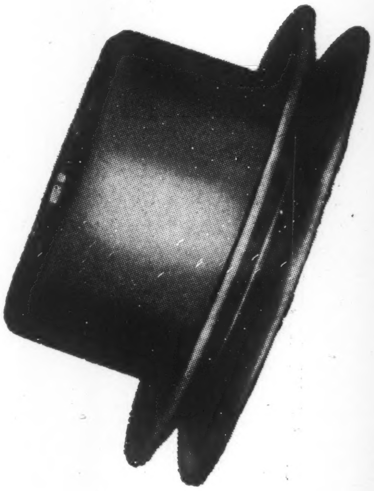
...and with every structural advantage of SPUNSTEEL design





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Circle Ⓛ 22 (a low carbon 18 and 8) is standard. In Circle Ⓛ 22-XM, a molybdenum variant has been added to increase resistance to many chemicals used in paper and textile industries. Circle Ⓛ 22-M contains selenium which improves the machining characteristics. Note the analyses and physical properties of each below. For additional information, send for our technical bulletin.

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Ⓛ22	0.07 Max.	1.25	0.75	19.50	9.00			75,000	36,000	50	135
Ⓛ22-M	0.07 Max.	1.25	0.75	19.50	9.00		Se. 0.25	80,000	40,000	45	160
Ⓛ22-XM	0.07 Max.	1.25	0.75	19.50	10.00	2.25		82,000	42,000	50	160

Lebanon CIRCLE L ALLOY AND STEEL Castings

Coolerator saves costly time

Training New Assembly Workers by using PHILLIPS SCREWS

Coolerator
Coolerator

Highlights from a comprehensive report by independent investigator of James O. Peck Co.—one of their studies of assembly savings made with Phillips Screws in leading plants...

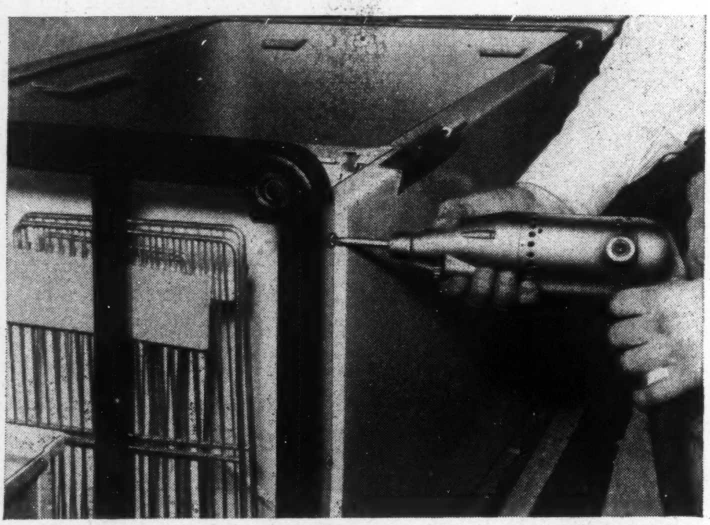
● "We made an important saving we hadn't counted on when we switched to Phillips Recessed Head Screws," said the foreman of Coolerator's assembly line. "Instead of the expensively long period usually required to train operators to drive slotted screws, we found that new people could start driving Phillips Screws with a few simple instructions. Since we use about 125 Phillips Screws in every Coolerator and our daily production is 800, there isn't much time for teaching anyone how to drive a screw.

"EASIER TO USE, especially in awkward or blind applications ... like fastening the black base to the bottom of the unit or attaching the ice container to the box. You have practically no control over slotted screws, while Phillips Screws are easy to line up.

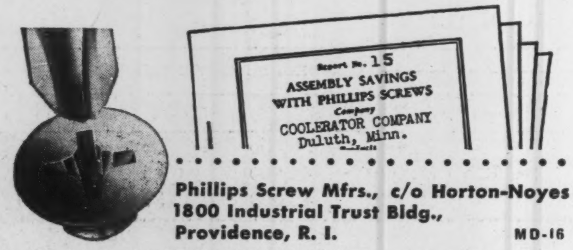
"STOPPED PANEL DAMAGE and burring of heads. Assembly people used to almost write their names on the sides of the units when a slotted screw driver slipped. That cost real money ... for disassembly, refinishing and reassembly, not to mention the disruption of the assembly line. Phillips Screws ended slips.

THE WHOLE STORY of this and other assembly studies in key plants ... covering metal, wood and plastic products ... will suggest similar savings to any production man. This coupon will bring you these reports—FREE. Mail it now.

Here's a tricky bit of "blind" driving ... through a small hole in the ice unit. With Phillips Screws, locating and driving is easier.



If ordinary slotted screws were used in fastening this black enameled base, inevitable driver slippage would do costly damage to the adjacent panels.



Report No. 15
ASSEMBLY SAVINGS
WITH PHILLIPS SCREWS
Company
COOLERATOR COMPANY
Duluth, Minn.

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Company ....

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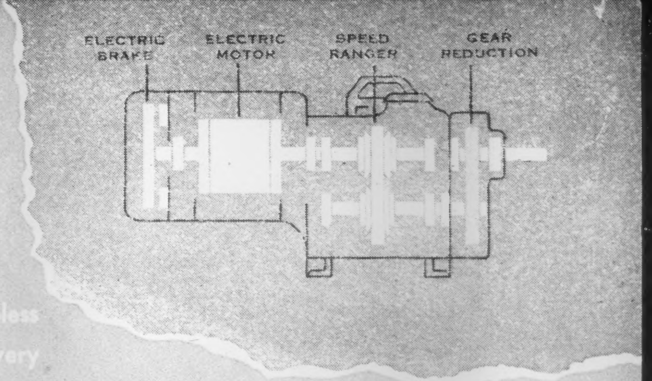

On thousands of applications in every field of manufacture, stepless variable speed operation assures exactly the right speed for every operation . . . for every operator . . . and for each change in the consistency or shape of the material being processed. Such variable speed operation pays off in higher rates of production, a more uniform better quality product and more efficient performance of your equipment and your operators.

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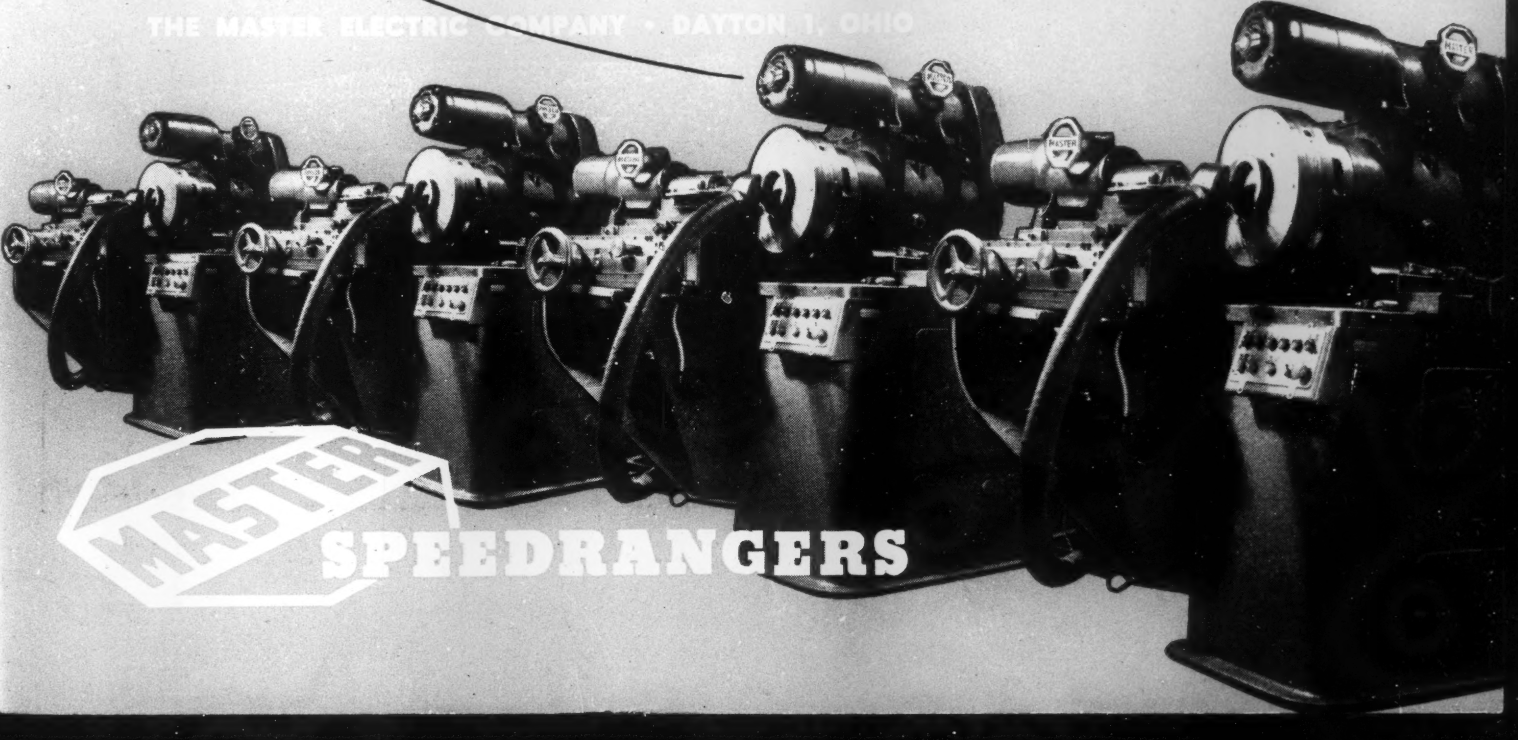

MASTER SPEEDRANGERS

GARVIN
HI-POWER
TAPPER
Tapered Roller
TIMKEN BEARING
EQUIPPED

Another New Machine Tool Relies On TIMKEN BEARINGS

The GARVIN "Hi-Power" Automatic Tapper pictured here, with a capacity up to 3″ diam. taps in cast iron, is the latest addition to the list of Timken Bearing Equipped machine tools, manufactured by the Western Machine Tool Works, Holland, Michigan.

Timken Tapered Roller Bearings are mounted on all transmission shafts besides the heavy duty splined spindle, for, like all precision machine tools, this automatic tapper requires accurate, dependable operation under very heavy loads and high speeds. Timken Bearings give the assurance of smooth, efficient performance, with reduced operating and maintenance costs.

For years leading machine tool manufacturers have relied on Timken Bearings to carry radial, thrust, and combined loads; to hold moving parts in constant alignment; eliminate friction and wear; simplify lubrication.

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